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PARTIAL CONTENTS

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AMERICAN GEOLOGICAL INSTITUTE

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CONTENTS

IGR TRANSLITERATION OF RUSSIAN

The AGI Translation Office has adopted the Cyrillic transliteration recommended by the U. S. Department of the Interior, Board on Geographic Names, Washington, D.C.

Alphabet		transliteration
А	а	a
Б	б	b
В	в	v
Г	г	g
Д	д	d
Е	е	e, ye (1)
Ё	ё	ë, yë
Ж	ж	zh
З	з	z
И	и	i
Й	й	y
К	к	k
Л	л	l
М	м	m
Н	н	n
О	о	o
П	п	p
Р	р	r
С	с	s
Т	т	t
У	у	u
Ф	ф	f
Х	х	kh
Ц	ц	ts
Ч	ч	ch
Ш	ш	sh
Щ	щ	shch
Ъ	ъ	"
Ы	ы	y
Ь	ь	'
Э	э	e
Ю	ю	yu
Я	я	ya

NOTES:

(1) "ye" initially, after vowels, and after ъ, ь ; "e" elsewhere; when written as "ë" in Russian, transliterate as "yë" or "ë".

Well-known place and personal names that have wide acceptance will be used. Some translations may include elements of previous German transliteration from the Russian; this occurs in IGR most commonly in maps and lists of references. The reader's attention is called to the following variations between German and English systems which may cause confusion when trying to check back to original Russian sources.

German	English
w	v
s	z
ch	kh
tz	ts
tsch	ch
sch	sh
schtsch	shch
ja	ya
ju	yu

SOVETSKAYA GEOLOGIYA (SOVIET GEOLOGY) IN TRANSLATION, 1960, NOS. 7 AND 8

CONTENTS, CRITIQUE, SELECTED PUBLICATION, AVAILABILITY OF TRANSLATIONS

The translation program of the American Geological Institute includes complete translation of the journal Sovetskaya Geologiya (Soviet Geology), beginning with the 1960 volume year. Each issue is translated cover-to-cover. The translated papers are reviewed by members of the staff of the Geology Department of the Virginia Polytechnic Institute under an arrangement with Professor Byron N. Cooper, Chairman. Papers of greatest significance and most general interest undergo additional editing and are published in full in International Geology Review. All other papers, not selected by the review group for publication in IGR, are available as individual translations, reproduced in photocopy form from the translation manuscript.

The table of contents of translated issues of Sovetskaya Geologiya is listed in International Geology Review, showing author, title, original journal pagination, and reviewer's comments of each paper not selected for publication. Those papers appearing in IGR in full are designated by a star (★).

> Orders for photocopies of translations not published in IGR should include the following information from the table of contents: Senior author, number of pages, price, and order reference number, i.e., "Nekrasov, 32 pp., $4.80, Order ref:SG60-1-2." Payment must accompany order. Send to: Translations Office, American Geological Institute, 2101 Constitution Avenue, N.W., Washington 25, D.C.

SOVETSKAYA GEOLOGIYA (SOVIET GEOLOGY) JULY 1960, NO. 7

CONTENTS AND TRANSLATION AVAILABILITY
Translation by Royer and Roger, Inc.

A review article, rather wordy, of general stratigraphy and distribution of general metalliferous provinces or areas where discoveries have been made. Interesting to get general scope but not interesting enough for publication. Translation is good. Lacks essential details.

Concludes that there can well be come Cu-Ni ores associated with trap rock intrusions and hence the latter should be investigated. Has a general separation in time and place of the Cu-Ni ores and the cuprite-pyrite-millerite ores. The latter may not be related to differentiated gabbro-diorite intrusions, but to widespread hydrothermal solutions. Paper is windy, poorly written or translated, and does not merit publication.

Finds relation between tin ores and granite and rocks, as well as major fault breaks. Ores range from quartz-cassiterite to cassiterite sulfide types. Low sulfide ores are abundant and tend to have also tungsten. Apparently represents a transition stage from one end to other, i.e. sulfide to quartz. Commonly much tourmalinization and alteration of country rock in stockwork. Not a bad article but narrow in interest and scope. No really new concepts.

This is really a stratigraphy and paleontology paper. It is interesting and describes sandstone-shale facies changes.

★Vakhrameyev, V.A., STRATIGRAPHY FROM PALEOBOTANICAL DATA OF JURASSIC AND LOWER CRETACEOUS CONTINENTAL DEPOSITS IN EAST SIBERIA AND THE FAR EAST.
pp.82-94 IGR, v.3, no.12 (this issue)

Aleksin, A.A., SOME PROBLEMS OF THE AERATION ZONE REGIMEN AND GROUND WATERS OF ARID REGIONS
pp.95-102 Photocopy 16pp. $2.40, Order ref:SG60-7-5

This paper never gets off the pad of basic elementary considerations, none of which are newly presented in this paper. It falls short of a contribution because it does not present any information other than rather commonly accepted facts and principles. Nothing new here at all.

★Polevaya, N.I., Murina, G.A., and Kazakov, G.A., ABSOLUTE-AGE DETERMINATION OF SEDIMENTARY ROCKS BY GLAUCONITES.
pp.103-115 IGR, v.3, no.12 (this issue)

Short Notes

Kukovskiy, Ye.G., PALYGORSKITE CLAYS IN THE UKRAINE.
pp.116-119 Photocopy 7pp. $1.05, Order ref:SG-60-7-6

A brief description and confirming tests of palygorskite clay in bentonite rocks. They are associated with hydromica.

Kuznetsova, M.A., and Kolesnikova, V.A., KARST WATERS IN THE TASHTAGOL IRON ORE DEPOSIT, GORNAYA SHORIA.
pp.119-121 Photocopy 4pp. $0.60, Order ref:SG60-7-7

An account of encountering a water-filled sink which flooded part of the mine at rate 2200 cubic meters per hour (6,000-7,000 gal/min). Contains exploration work in karst ground.

Seliverstova, M.I., Komarov, A.M., and Speyt, Yu.A., THE INA IRON-ORE DEPOSIT IN THE ALTAI.
pp.121-122 Photocopy 4pp. $0.60, Order ref:SG60-7-8

Contact metamorphic type magnetite skarn deposit adjacent to granite. Ore bodies up to 50 m thick and 800 m long. Grade 43.6% Fe. Reserves 88 mill. tons of category B (visible) and 15.4 mill. tons of C (assumed). Probable ore 200-300 mill. tons.

Cherepanova, Ye.P., Yemel'yanko, N.I., and Nesterenko, A.D., THE AMPALYK IRON-ORE DEPOSIT.
pp.122-123 Photocopy 3pp. $0.45, Order ref:SG60-7-9

Announces acceptance of ore reserves of about 130 mill. tons of 30 - 35% Fe in magnetite skarn deposits at contact between groundwater and various sedimentary rocks including considerable limestone. Not adequate for production.

History of Geological Sciences

Tikhomirov, V.V., and Voskresenskaya, N.A., MEMORABLE DATES FOR APRIL-SEPTEMBER 1960, REVIEW 27.
pp.124-128 Photocopy 13pp. $1.95, Order ref:SG60-7-10

Reviews of anniversaries of Messerschmidt, D.G., Eversman, E.E., Amalitskiy, V.P., Walter, Johannes, Zhemchuzhnikov, Yu.A., Dybovskiy, V.Ya., and others. Typical reviews of these various Russian and European geologists. Informative.

In the Ministry of Geology

PROBLEMS IN THE IMPROVEMENTS OF MINING GEOLOGICAL SERVICE - STATUS OF GROUND-WATER STUDIES.
pp.129-133 Photocopy 5pp. $0.75, Order ref:SG60-7-11

An account of their need for better coordination of geology and mining. Reflects the lack in the Russian economy of a built-in mechanism for weeding out inefficient exploration and development practices.

The Foreign Geological Surveys

Nemilova, A.V., FIELD STUDIES BY THE INDIAN GEOLOGICAL SURVEY 1957-1958 AND ITS 1958-1959 SCHEDULE.
pp.133-136 Photocopy 7pp. $1.05, Order ref:SG60-7-12

An account of nine expeditions of Russian geologists in India. Found considerable coal and other deposits. Mapped over 3,625 sq. mi. Report is strictly a listing of work done in 1957-58.

Scientific Notes and News

Fedyuk, V.I., FOR CONTINUING PROGRESS IN EXPLORATION GEOPHYSICS.
pp.136-141 Photocopy 17pp. $2.55, Order ref:SG60-7-13

A resumé of methods used and new proposed geophysical exploration and development. New development in instrumentation are discussed. Limited interest.

Belyayevskiy, N.A., and Ivanov, Yu.A., RESULTS OF THE BAKU CONFERENCE ON THE EXPERIENCE EXCHANGE IN GEOLOGICAL SURVEYING AND EXPLORATION WORK IN THE SOUTH OF THE EUROPEAN U.S.S.R., CAUCASUS° AND CENTRAL ASIA.
pp.141-147 Photocopy 18pp. $2.70, Order ref:SG60-7-14

A repetitious report on past geological and physical work and plans for a proposed five to seven year plan for similar work. It is a paper of rather limited interest.

Markov, F.G., FIRST INTERNATIONAL SYMPOSIUM ON GEOLOGY OF THE ARCTIC (CALGARY, CANADA).
pp.148-151 Photocopy 11pp. $1.65, Order ref:SG60-7-15

This report by a well-informed Russian geologist might make interesting reading although the symposium will undoubtedly be reported on by the Alberta Society of Petroleum Geologists.

Reviews and Criticism

Ustiyev, Ye.R., REVIEW OF K.N. RUDICH'S BOOK "IGNEOUS ACTIVITY AND TECTONIC FEATURES OF THE SARYCHEV RANGE (THE YANA-KOLYMA FOLDED PROVINCE)".
pp.152-154 Photocopy 6pp. $0.90, Order ref:SG60-7-16

A general review of book on northeastern Russia. Mainly concerns the first integrated account of one of Russia's little known areas. Not of broad enough interest.

Kosygin, M.K., and Roslyakov, G.V., REVIEW OF A.A. YAKZHIN'S BOOK, "SEARCH AND EXPLORATION FOR MINERAL DEPOSITS."
pp.154-155 Photocopy 5pp. $0.75, Order ref:SG60-7-17

This is a book review. It is a rather thorough one and is, therefore, rather enlightening. However, it is of doubtful value so far as republication is concerned.

Vlasov, G.M., LETTER TO THE EDITOR.
pp.155-157 Photocopy 5pp. $0.75, Order ref:SG60-7-18

This is a discussion of a previously published paper (Sov. Geol. 1959, no. 8, Shipulin, F.K., "A Hydrothermal Deposit of Native Sulfur in the Mongolian People's Republic") and a rather good one. Vlasov counters the popular notion that hydrothermal deposits of sulfur are not significant.

SOVETSKAYA GEOLOGIYA (SOVIET GEOLOGY) AUGUST 1960, NO. 8

CONTENTS AND TRANSLATION AVAILABILITY
Translation by Research International Associates

Semenov, A.I., Labazin, G.S., Grusheva, V.G., and Tatarinov, P.M., ON THE METALLOGENETIC MAP OF THE U.S.S.R. AT SCALE 1:5,000,000.
pp.3-25 Photocopy 38pp. $5.70, Order ref:SG60-8-1

A detailed description of the preparation of a new map showing relationship between mineralization and ore deposits with tectonism, geologic time, magmatism, etc. The map and this article would be valuable for someone interested in studies of metallogenetic provinces and the development of ore deposits. Very similar to the deposits of North America but also significantly different. Rather long and wordy but a fairly good summary.

Kazarinov, V.P., THE SEDIMENTARY COMPLEXES OF WEST SIBERIA.
pp.26-38 Photocopy 22pp. $3.30, Order ref:SG60-8-2

An attempt to group the sedimentary rocks of this area into large genetic units or associations. These are said to be dependent for their characteristics on

corresponding tectonic cycles. Not a very stimulating article. Reminiscent of Sloss's "operational units."

Kuznetsova, V.N., STRUCTURAL PECULIARITIES AND ORIGIN OF THE MAIN LODE OF THE KIYEMBAY CHRYSOTILE-ASBESTOS DEPOSIT.
pp.39-49 Photocopy 16pp. \$2.40, Order ref:SG60-8-3

This article would be for a rather limited audience at most.

Sokolov, Ya.N., Venediktov, S.N., and Zakharchenko, A.I., BASIC STRUCTURAL TYPES OF QUARTZ CRYSTAL-BEARING VEINS OF THE BET-PAK-DALA AND THE WESTERN AND NORTHERN NEAR BALKHASHYYE.
pp.50-65 Photocopy 24pp. \$3.60, Order ref:SG60-8-4

Gives a structural and physical description of different types of quartz veins. Finds there are older, higher temperature (250-400°C-by liquid inclusions) veins in which the quartz inclusions are rich in chlorides and younger, secondary types of quartz in vugs which are lower temperature and tend to be rich in bicarbonates. In sulphate-rich inclusions of mineralized areas, no hope for optical quartz. Article not too well written or translated and of relatively local interest.

★Potapov, I.I., CLASSIFICATION SCHEME FOR TECTONIC FORMS.
pp.66-74 IGR, v.3, no.12 (this issue)

★Yakushova, A.F., NEOTECTONICS OF EAST AND CENTRAL CIS-CAUCASUS.
pp.75-86 IGR, v.3, no.12 (this issue)

Dubov, R.I., A METHOD FOR GEOPHYSICAL EXPLORATION OF POLYMETALLIC DEPOSITS IN TRANSBAIKAL.
pp.87-101 Photocopy 23pp. \$3.45, Order ref:SG60-8-5

A review of geophysical methods applied to mineral exploration of various modes of formation and occurrence. Emphasis is placed on close correlation of field evidence and geophysical measurement. Limited interest. No startling or apparent new application or new instrumentation.

★Zhevlakov, A.V., MINERAL WATERS OF BOHEMIA.
pp.102-114 IGR, v.3, no.12 (this issue)

Short Notes

Shilo, N.A., and Orlova, Z.V., MIDDLE QUATERNARY GLACIAL SPORE AND POLLEN COMPLEX OF ALLUVIAL DEPOSITS IN THE KOLYMA RIVER BASIN.
pp.115-119 Photocopy 8pp. \$1.20, Order ref:SG60-8-6

Area is in northeasternmost Siberia. Paper describes attempts to recognize the several glacial and interglacial stages of the Quaternary by means of pollen recovered from several levels of river-terrace sediments. Floral lists from several terraces and a pollen illustrated. Of interest to Alaskan Pleistocene specialists perhaps. Not of general interest.

Suvarova, N.P., ON THE LENIAN STAGE OF THE LOWER CAMBRIAN OF THE EAST SIBERIAN PLATFORM.
pp.119-126 Photocopy 15pp. \$2.85, Order ref:SG60-8-7

Area is southeast of Yakutsk about midway between Yakutsk and the coast of the Sea of Okhotsk in eastern Siberia. Paper describes several sections consisting of limestone and shale, bearing trilobites mainly. Correlations and the Lower-Middle Cambrian boundary of the part of Siberia are discussed. Fossils from the various sections are listed. Interesting to Cambrian and trilobite specialists but not for general reader.

Martinson, G.G., THE AGE OF MESOZOIC CONTINENTAL DEPOSITS IN THE SOUTHERN PART OF THE SIBERIAN PLATFORM. NO. 8, 1960.
pp.126-131 Photocopy 12pp. \$1.80, Order ref:SG60-8-8

Reviews faunal and floral evidence for correlations in that area. Concludes Upper Jurassic and Lower Cretaceous deposits present, as well as formerly recognized Lower and Middle Jurassic. Mostly, but not entirely, continental deposits with coal-producing strata in some areas. Upper Jurassic and Cretaceous may have been laid down in separate basins. Numerous fossils listed. Not of general interest.

Lazarenko, N.I., "WORMY" ROCKS IN THE UPPER VISEAN OF THE WESTERN DONBAS.
pp.131-133 Photocopy 5pp. \$0.75, Order ref:SG60-8-9

Describes morphology of worm trails and tubes in Visean rocks of Donets

coal basin north of Sea of Azov with object of using them to solve local stratigraphic problems in that area. Not of general interest.

Romanovich, I.F., ON THE ORIGIN OF CHLORITE ROCKS OF THE KIRYABINSK TALC DEPOSIT.
pp.133-137 Photocopy 9pp. $1.35, Order ref:SG60-8-10

[Reviewer's comments not available.]

In the Ministry of Geology

THE WORK OF THE INTERDEPARTMENTAL COMMITTEE ON THE QUESTIONS OF OIL AND GAS CAPACITY IN THE WESTERN REGIONS OF CENTRAL ASIA.
pp.138-139 Photocopy 3pp. $0.45, Order ref:SG60-8-11

Probably not suitable for publication as it merely outlines a plan for evaluating oil and gas prospects. A planning agency such as the U.S. Geological Survey might be interested.

RESULTS AND PERSPECTIVES OF GEOLOGICAL SURVEYING ON THERMAL INSULATING MATERIALS AND LIGHT FILLERS.
pp.139-140 Photocopy 4pp. $0.60, Order ref:SG60-8-12

Only a little basic general information is given. Not of general interest.

THE RESULTS OF THE WORK OF THE GEOPHYSICAL SECTION OF THE GEOLOGICAL COUNCIL OF EXPERTS.
pp.140-141 Photocopy 3pp. $0.45, Order ref:SG60-8-13

No general interest.

Scientific Notes and News

Belyayevsky, N.A., and Golov, A.E., SCIENTIFIC SUMMARY OF THE ANNIVERSARY SESSION OF THE GEOLOGICAL INSTITUTE (WARSAW, 1960).
pp.142-147 Photocopy 13pp. $1.95, Order ref:SG60-8-14

Article starts with a bit of propaganda but then gives resumés of new findings and problems on the geology of Poland. An interesting summary.

Reviews and Criticism

Kozlov, V.P., and Sokolov, V.A., REVIEW OF A.L. KOZLOV'S BOOK "THE FORMATION AND DISTRIBUTION OF OIL AND GAS DEPOSITS."
pp.148-153 Photocopy 14pp. $2.10, Order ref:SG60-8-15

This very critical review is an interesting commentary on the poor understanding of basic concepts of geology by a geologist who doesn't mind, or doesn't know he is showing his ignorance in public. The review is really a scathing denunciation and from this standpoint might be used as filler in an oil and gas series.

Neiman, V.B., CERTAIN REMARKS ON THE ARTICLE OF B.P. ZHIZHCHEUKO, "THE REGION OF REMOVAL OF TERRIGINOUS MATERIAL AND CRUSTAL MOVEMENT," (SOV. GEOL. 1959, NO. 12).
pp.153-154 Photocopy 3pp. $0.45, Order ref:SG60-8-16

Cites disagreement with certain concepts in article. Not of interest.

DEVELOPMENT OF THE EARTH AND ITS TECTOGENESIS[1]

by

V. V. Beloussov[2]

REVIEWER'S NOTE

This lengthy article barely holds together in places, but it embodies a number of provocative theses including one dealing with the original formation of continents which is rather strongly at variance with J. Tuzo Wilson's ideas on continental evolution. This paper will make many American geologists (and European Alpine geologists) see red, but the idea that vertical, rather than horizontal, crustal movements are of first-order importance makes a great deal better sense. The writer's "stages" in formation of the globe is rather tenuously based on much too local and general relations, but his concepts have genuine appeal nevertheless. This article will have wide appeal and interest for geologists the world over and may stimulate them to do more critical thinking on fundamental tectogenesis.

ABSTRACT

It is assumed that the earth having been formed in a cold state was warmed up by radioactive heat. Its further evolution was determined by differentiation of its constituent material through successive smelting from the mantle of relatively light components and subsequent displacement upward. The most intensive differentiation in the upper "layer" (evidently at depths of from 100 to 200 km) causes strong vertical movements of the crust. After that is exhausted slower differentiation of the deeper "layer" (evidently at depths of from 200-300 km) is manifested on the surface in slow oscillatory movements forming platforms. Further heating activates the material of much deeper layers (as deep as 900 km) and causes large masses of basalt to rise to the surface. This ascent of basic material induces post-platform activity (observed in Central and East Asia), extrusions of plateau basalts and, finally, destruction of the continental crust through melting, metasomatic replacement and dissolution into the large volume of superheated basalt. As a result of destruction of the continental crust, large grabens, mediterranean seas and ocean basins have been formed. The development of tectonic processes is profoundly influenced by 1) the formation of deep faults in the crust and upper mantle which determine the routes of material distribution and 2) by the "the-lid-on-the-kettle-with-boiling-water" phenomenon. The last involves periodical accumulation of heat at depth, expansion of the mantle, the opening of deep faults, and quick removal of heat to the surface, together with heated material, along the faults. The periodicity of tectogenesis may be connected with this mechanism. It is assumed that up to now the earth has been warming up. Traces of tension of the crust accompanying the process of formation and expansion of the oceanic deeps are therefore considered to be an expression of a more general tension of whole crust and the upper mantle of the expanding earth. The expansion process expressed in the opening of deep faults and uplift of deep-seated material to the surface along faults may be nonuniform, affecting some regions earlier than others, which causes the simultaneous existence of several regions in different stages of development. The author accepts the idea of deep-seated origin of sea-water, which rises from the mantle during subsidence of the oceanic basins and destruction of the continental crust. The author divides the history of the earth into two partly overlapping stages: granitic and basaltic. - Auth English summ.

* * *

BASIC GEOTECTONIC REGULARITIES

In a number of earlier works, this author has already outlined the problems of the relationship of tectogenesis and the general development of the earth [1, 3, 6, 7]. There are reasons to believe that now it becomes possible, with the help of latest data of geophysics, geochemistry, and tectonics, to make another step toward the solution of this most difficult problem, and unite in a general concept a larger array of deep-seated and geotectonic processes than was ever before possible. In this paper the author confines himself to a general exposition of such a concept, with many details to be worked out later on. It is believed that the nature of this concept is such as to render such a detailing possible, both qualitatively and quantitatively.

The premises for our analysis of the tectonic development of the crust are as follows. Inasmuch as folding is a phenomenon of vertical movements of the crust [8], it is possible to confine ourselves to a consideration of the latter without looking for independent causes

[1]Translated from Razvitiye zemnogo shara i tektogenez: Sovetskaya Geologiya, 1960, no. 7, p.3-27.

[2]Institute of Earth Physics, Academy of Sciences of the U.S.S.R.

of the former. Faulting movements, too, are a result of either oscillatory movements or folding. However, there is a group of rifts which appear to be quite independent in their importance in the development of both the crust and deeper reaches of the earth. These are the primary deep rifts. Originating in a certain sequence in different localities, they determine the block structure of the crust and provide avenues of escape for the rising of deep-seated material.

Igneous phenomena are important in their own right, which renders their analysis particularly meaningful in determining the relationship between the movements of the crust and deep-seated processes. It is obvious that any general concept will have to explain the sequence of igneous phenomena under geosynclinal, platform, and other conditions, be it only a general outline with a possibility of deviation in its details.

During a certain interval of geologic history, the evolution of continental segments of the crust generally proceeded from geosynclinal to platform conditions, i. e. from the conditions of contrasting and intensive undulatory movements to those of extremely weakened movements of the same type. This evolution proceeded on the background of a tectonic periodicity, determined on the whole by the development of the so-called general oscillations of the crust – spatially uncompensated subsidences and uplifts occurring almost simultaneously in geosynclines and platforms, although of a greater amplitude in the former than in the latter. These general oscillations are known to possess a periodicity of a different order, specifically major movements with a periodicity of 150 to 200 million years constitute what is called geotectonic cycles. We have previously pointed out that such a cycle is culminated in a general uplift marked by the intensification of the undulatory movements and by their greater amplitude in both larger and smaller segments [4, 7].

The most recent geologic time witnesses a "post-platform activation" in some provinces; it is expressed in a revival of undulatory movements in places where they died down once, at the termination of geosynclinal conditions.

This post-platform activation is best expressed in Tien-Shan. However, the earlier concept of "activation" must be considerably broadened. The immense area of Central and East Asia is witnessing a special kind of crust development wherein the post-platform activation constitutes but part of a whole. Besides the contrasting tectonic differentiation of segments representing earlier platforms (Tien-Shan, Sayans, Altai, a number of ranges in China), there are uplifts of such large plateaus as the Tibetan and the Pamirs, taking place in sites of geosynclines of different ages, including the Alpine; the formation of the Baikal-type grabens, along with troughs and uplifts of a Trans-Baikal type (widely distributed in Mongolia as well as in the Trans-Baikal region); and the formation of the West Siberian interior trough. These particular phenomena were initiated at different times in different provinces of Asia, but nowhere earlier than the beginning of the Mesozoic, with some of them being typical of the latest interval of geologic time – the Neogene and Anthropogene.

It appears that all these phenomena, different from those typical of a "normal" development of geosynclines and platforms, suggest a brand new trend replacing the earlier geosyncline-platform development trend. We believe that connected with this new trend may be the formation of oceans and the Mediterranean type seas (see below). It appears that they were initiated not earlier than the Mesozoic – much later, in many instances. In the Cretaceous, Tertiary, and Quaternary, the oceans grew at the expense of the continents, and were considerably deepened. We believe that fairly convincing geologic evidence has been brought up to support such a view [2]. However, inasmuch as the concept of a secondary nature and the youth of present-day oceanic troughs has run into objections, the author deems it expedient to spend more time on this subject.

Those objections are not to geologic facts which suggest the growth of the oceans in the Mesozoic and Cenozoic. Our opponents contend that such concepts contradict differences in the structure of the crust under continents and under oceans, as established by geophysical methods [17, 18, 20, 22]. Indeed, a radical transformation in the crust is obviously necessary in the change from a continent to an ocean: the crust must become considerably thinner and the so-called granite layer must be done away with, somehow. Ye. N. Lüstich states in his recent paper that such a transformation is impossible, energy-wise [20]. We believe that such statements are fraught with danger. First of all, we must be quite sure that geologic evidence corroborates the growth of oceans and mediterranean seas at the expense of continents. If such a phenomenon is actually present, we cannot ignore it just because we are at a loss, at the present time, to explain the mechanics of it. On the contrary, we must abandon the alleged certainty as to what is or is not possible on this earth, and to strive for an explanation of this "oceanization" of the crust, always mindful that we know very little, as yet, of the properties of deep-seated substance.

The author [2] has cited the following facts as evidence of a late formation and further growth and deepening of oceans and deep seas:

1) Evidence that present-day oceans were dry land which provided a path of migration for plants and animals and constituted a source of clastic material (we mean here a land connection between the Gondwana continents, in the upper Paleozoic; a land connection across the North Atlantic from Europe and North America; a land connection between islands of Indonesia and the continent and between the islands of

Japan and the continent, as well as between New Zealand and Australia, persisting into the Neogene; and sources of clastic material in the Atlantic, northwest of Scandinavia, in the lower Paleozoic; in the Atlantic, east of the Appalachians, in middle and upper Paleozoic; and in the Atlantic, west of the Congo basin, at the beginning of the Mesozoic.

2) The former and definite development of continental deposits of the Karoo basin beyond the present-day continent of Africa, and the presence of granite boulders brought by upper Paleozoic glaciers from the direction of the present-day Indian Ocean.

3) Incontrovertible paleogeographic data on the presence of an elevated land on the site of the Mediterranean and Caribbean Seas which now have an oceanic type crust. Especially interesting in regard to those seas are the works of Behrmann [40] and Butterlin [43]. There also are incontrovertible paleogeographic data pointing to the presence of dry land and shallow seas during the long geologic history, at the sites of the Black and South Caspian Seas where the present crust is of an oceanic type [13, 25, 26, 27].

4) Guyots in the Pacific and Atlantic oceans, along with the results of drilling in atoll islands, suggesting recent and considerable deepening (post-Cretaceous) of oceans;

5) The general "superimposed" nature of the Atlantic and Indian Oceans and of many marginal and interior seas with relation to the continental structure, as well as a "fractured" nature of the latter;

6) Coastal flexures, especially well expressed along the Atlantic coast (Greenland, United States, Africa).

Most of these data are by no means new; until recently, they were regarded as an adequate substantiation for the concept of a secondary nature for oceans. A revision of this concept is due entirely to the discovery of the above-mentioned difference in the deep crustal structure under continents and oceans. However, as long as these geologic data still stand and do not have any other explanation, ignoring them cannot be justified. Nor is their explanation of the kind offered, for instance, by Ye. N. Lüstich [20] acceptable. That author assumes that individual segments of oceanic crust existed for a long time in an uplifted position, isostasy notwithstanding; then they went down, whereby equilibrium was achieved. In addition to the fact that such an anomalous position of these blocks has not been given any explanation, it is extremely strange that they all went down at the same recent epoch and have become isostatically. balanced, as we observe them now. Moreover, strictly speaking, a single authentic instance of "oceanization" of the crust is enough to reveal the full scope of the problem of its transformation. As long as granite pebbles were, as early as the Miocene, carried from the direction of the Tyrrhenian Sea [40] whose present bottom has definitely oceanic structure [18], and as long as similar anomalous changes have been registered for the Black and Caribbean seas, the problem of "oceanization" in any of those instances is not substantially different from that for the Pacific and for the "World Ocean" as a whole. Granted the validity of isostasy and of a somewhat different crustal structure in shallower and deeper segments of a basin, the simple fact of deepening of an oceanic trough, as established from guyots and the drilling results in coral reefs, is sufficient, by the same token, to pose the same problem.

CHEMICAL COMPOSITION OF THE CRUST AND THE MANTLE

Before tackling the problems which confront us, it is necessary first of all to have an idea of the composition of that substance which houses the deep-seated processes described below.

The so-called "granite" layer of the crust is known to be heterogeneous. It takes in sedimentary and metamorphic rocks, gneisses and granites. In any event, gneisses and granites appear to make up the bulk of it. The composition of the "basalt" layer is considerably more obscure. There is geophysical and geologic evidence in favor of its basalt or more precisely gabbro composition; however, there are some doubts on that subject. If we assume that the causes for tectonic movements, as well as the principal sources of magma, lie below the crust and that this crust is to a considerable extent a passive subject of deeper processes, the problem of the composition of that "basalt" will lose some of its urgency. We believe it most probable that the upper portion of that layer is represented by a mixture of granite, gneisses, and basic rocks (gabbros) while most of it consists of basalts (or gabbros) and represents that region where the Mohorovičić discontinuity is displaced up or down, depending on temperature and pressure and the reversible changes from eclogite to basalt.

Extremely important is the problem of the material composition of the upper mantle. It is in these layers, located within a few hundred kilometers of the surface, that the cause of tectonic and igneous processes seem to be concentrated. Volcanic foci are present at depths between 60 and 200 km. Deep-seated earthquakes have been recorded down to depths of approximately 700 km.

Inasmuch as granites, as has been convincingly established, are of a metamorphic origin and there is no need of supposing that they have come out as such from the mantle, the latter should be

regarded mostly as the source of basalt. The volume of basalt coming from the depths is immense. Especially impressive are basalt flows on oceanic bottoms; likewise, the volume of basalt traprock on continents is quite large. Of interest in this connection is the considerable uniformity in the chemical composition of basalt of different ages and in different provinces. All other igneous rocks proper, from ultrabasic to acidic, do not compare with basalt in their volume, and can be fully explained by a differentiation of basalt or else its "contamination" by crustal rocks.

Viewed in this light, it is rather improbable that the upper mantle consists, as is often supposed, of such ultrabasic rocks as peridotite. To be sure, basalt can be derived from peridotite through differentiation, for instance through a separation of comparatively fusible components. It is hardly probable, however, that the products of such differentiation were stable in their composition; and it is quite incomprehensible that the original rock itself comes up to the surface in amounts quite subordinated to those of basalt.

Somewhat more attractive in this connection is the hypothesis of a basalt composition for the mantle, provided however that the mantle basalt exists as eclogite. Such a hypothesis was proposed at one time by Fermore, Goldschmidt, Holmes, and Birch, and quite recently by Lovering [51]. This last author believes that his hypothesis fits well the new data on the average composition of meteorites and on the physical properties of the upper mantle. He supposes that the upper 60 percent of the mantle is eclogite, below which there lie peridotite (35 percent) and dunite (5 percent). From this point of view, the Mohorovičić discontinuity appears to be the boundary of a phase transition from basalt (or gabbro) under low pressures to eclogite at high pressures, rather than a boundary between different materials. The phase transition is determined on the whole by a pressure union of some feldspar molecules into molecules of jadeite, omphacite, and garnet. Inasmuch as, in this instance, the rises in temperature and pressure work in opposite directions, a temperature rise at the same pressure or else a pressure drop at the same temperature, will change some of the eclogite to common basalt and bring about a corresponding lowering of the Mohorovičić discontinuity. In this process, the volume of material increases by about 15 percent and the basalt surface rises. As the temperature drops or the pressure rises, some of the basalt at the base of the crust will change to eclogite, which should raise the Mohorovičić discontinuity, reduce the volume of basalt and downwarp its upper surface. Thus, viewed in this light, the rise and fall of the Mohorovičić discontinuity are not related to a transfer of material or to its flow and ebb, but rather to a change from one phase or state to another. This concept facilitates understanding of many deep processes.

We believe it probable that an eclogite composition of the crust extends to the depth of an abrupt change in the rate of acceleration in the propagation of seismic waves, i.e. to 900 m from the surface (base of the "Golitsin layer" or layer "C" of the mantle).

V. A. Magnitskiy believes it possible that the change in physical properties in layer "C" with depth, as assumed from the change in the propagation velocity of seismic waves, can be explained by a change from the ion to a covalent nature of bond, without any recourse to the change in the chemical composition of matter [23]. That assumption has been corroborated by further investigations [24]. As to the source of ultrabasic rocks, the small volumes of them observed on the surface can be explained by a local differentiation of the basaltic source material, taking place in individual molten hearths. A major source of such rocks may be the base of that upper layer of fusing and differentiation with which we shall deal below.

As long as the material exchange between the surface and the interior is confined, as we believe, to these depths, we shall not go, at this time, into the composition of deeper layers of the mantle, let alone the earth's core.

DIFFERENTIATION IN THE UPPER LAYER OF THE MANTLE BY FUSING, AND ITS TECTONIC CONSEQUENCES

According to the currently accepted hypothesis, worked out by O. Yu. Schmidt [39] in this country, and by H. Urey [59] in the U. S., the earth was formed by the adhesion of cold dust-like particles of a protoplanet swarm surrounding the sun. Because of such an origin, the earth was originally cold and quasi-homogeneous insofar as its component particles, with their homogeneous chemical composition, were distributed within it quite haphazardly.

The most complete presentation of the thermal history of the earth, from this point of view, is given in a number of works by Ye. A. Lyubimova [19. 52], with consideration given to the probable redistribution of radioactive sources of heat in the differentiation process, as well as to the heat conductivity changes with depth and temperature. However, the unreliability of parameters involved render such thermal calculations quite problematical. Moreover, Lyubimova considered molecular heat conductivity and radiation as the only means of heat transfer, without taking into account the loss of heat with material, which we are inclined to regard, as we shall see below, as paramount in thermal processes taking place in the interior of the earth. However, despite the condi-

tional nature of these calculations, we believe that their principal result can be accepted as the basis for further discussion.

The main result of Ye. A. Lyubimova's calculations is the establishment of thermal autonomy for the interior of the earth, beginning at a depth of about 500 km. Because of the low heat conductivity of the mantle, radioactive heat generated below that depth is virtually not conveyed outside. For that reason the interior of the earth has been warming up and this process is still continuing. In the outer portion of the mantle, on the other hand, down to a depth of about 500 km, a long warming up period should be followed by a cooling off. According to Lyubimova's calculations that started 1 to 2 billion years ago. These figures, however, are extremely unreliable.

A correlation of the temperature progress with the fusing temperature for mantle at various depths leads to the assumption that radioactive heat might lead to fusing of material, first of all in a layer located in the upper mantle (Lyubimova gives a depth of 100 to 700 km). The position of that layer is determined by the combination of temperatures and pressures: above that layer, the temperatures are too low for fusing; below it, the pressure is too high. It is quite reasonable to suppose that this layer of possible fusing has something to do with a layer of lower propagation velocities for seismic waves, located at depths of 100 to 250 km [38, 48].

Depending on local temperatures and pressures at different levels of that layer, either all of the material can be fused or else those of its components which have a lower melting point.

Within that molten layer, conditions for a gravity differentiation, are promoted, during which lighter components accumulate on top with the heavier ones below. In his earlier works, [1, 3, 7], the author has voiced his opinion to the effect that a differentiation of the earth substance by density is the paramount deep process and the principal source of energy for tectonic movements and igneous activity.

We now define our concepts of the mechanics of this differentiation. One of its important factors is the melting-out of readily fusible components also having the lowest density. The great importance of selective melting in the earth's history has been pointed out by A. P. Vinogradov [11, 12]. The same view is held by V. A. Magnitskiy [21, 22], J. T. Wilson [10], and others.

This author has postulated that, because of the dissimilar differentiation conditions at various depths, the differentiation appears to proceed on different levels — independently and at a different rate on each level [7]. He pointed out that the movements of the crust can be traced to the effect of at least two levels: the upper, with a more intensive differentiation, which is the source of crustal movements in geosynclines; and the lower, with a slower differentiation, which is the source of movements expressed in their pure form in platforms. The author has also stated that the "platform" crustal movements are not confined alone but also affect the geosynclines where they constitute a background for more intensive geosynclinal movements proper, masked to a considerable extent by the platform movements. N. S. Shatskiy [35] has cited instances of deep "platform" movements clearly "transpiring" through the geosynclinal. Viewed in this light, the transition from geosynclinal to platform conditions appears to be determined by the cessation of differentiation in the upper story, whereupon only the lower story processes are reflected on the surface, in their pure form.

The differentiation products which are formed in the molten layer are lighter than the enclosing mantle material (eclogite). Accordingly, they tend to rise up while products of the same differentiation, heavier than eclogite, tend to sink. Present among the first are not only those light components which concentrate at the top of the molten layer but also basalt obtained from the complete fusing of eclogite – because basalt is lighter than eclogite.

It may be supposed that the buoying of light material is accomplished by a mechanism similar to that operative in the buoying of salt in diapir bodies. Growing up from the surface of a molten layer of a comparatively light material are columns which intrude the overlying heavier material, push it aside, and force it to sink to whence they came. In this process, light material gradually gravitates toward the columns, as if sucked in by them. A similar process is assumed for the lower part of the molten layer where material heavier than eclogite is concentrated. Here, too, heavy material is found above the lighter, thus creating conditions similar to those prevailing at the top of the molten layer. The underlying lighter material rises up while the overlying heavy material sinks to exchange places with it.

The entire complex of these processes – fusing, differentiation, bouying and sinking of material – must be substantially affected by deep rifts, insofar as they lead to a drop in pressure; in so doing, they promote, together with the temperature rise, fusing, differentiation, and vertical transfers. Thus a development of deep rifts, along with the temperature regimen, affects the depth of occurrence for the molten layer, its thickness, the intensity of the vertical material exchange, and the place and form of vertical flows. It is reasonable to suppose that molten products at the loci of such deep rifts rise up and descend along them, not

in columns but rather in ridges trending with the rifts.

Differentiation at the top and bottom of a molten layer proceeds under different conditions. At the top, it goes on at lower pressure and with lower viscosity. Thus, it should proceed more intensively. It is probably promoted by the fact, as we shall see, that deep rifts penetrate the top of the molten layer but do not reach its base. The greater intensity of the material exchange process at the top of the molten layer is expressed in a greater velocity of vertical transfer and a closer position of rising columns and ridges of lighter material.

RELATIONSHIP BETWEEN THE MANTLE DIFFERENTIATION AND CRUSTAL MOVEMENTS

Upward flows of light material and downward flows of heavy material produce corresponding uplifts and subsidences in the crust. The energy differentiation in the upper level, i. e., at the top of the fusing layer, creates a contrasting differentiation of the crust into intensive uplifts and subsidences typical of geosynclines. Vertical movements of much more viscous material at the base of the layer are developed at a much slower rate and are expressed in larger flows. Such movements are regarded as the cause of undulatory platform movements.

We believed at one time that the cessation of differentiation in the upper level, with a continuing differentiation in the lower level – which marks the change from geosynclinal to platform conditions – is brought about by the fact that the more rapid differentiation of the upper story achieves an earlier equilibrium in the distribution of material. It was supposed that differentiation ends when its material resources are exhausted. Undoubtedly, that factor is operative in the cessation of geosynclinal differentiation in the upper story. It is probable, however, that the main factor in the cessation of differentiation is the cooling which spreads downward throughout the mantle, as suggested by Lyubimova [19]. This cooling, related to the entire temperature regimen in the earth's interior, may discontinue at a certain instance the differentiation and the vertical material exchange in the upper geosynclinal story, and thereby cause the surface changes from geosynclinal to platform conditions.

It should be emphasized at this point that an important aspect of the physics of these deep processes is the fact that much more heat is conveyed to the surface by the process of differentiation and vertical circulation in the mantle than by heat conduction. In turn, the intensive vertical circulation of material in the upper level considerably hastens cooling of the latter, its "freezing up." In the meantime, in the lower platform level, where temperatures continue sufficiently high, vertical circulation goes on. Thus, based on these concepts, the transition from geosynclinal to platform conditions is related to the process of a "secular" cooling of the upper mantle, promoted by a vigorous vertical circulation of material.

This postulated relationship of undulatory crustal movements with deep-seated processes affords an explanation for some essential features of such movements. Thus it becomes understandable why the provinces of uplift and downwarping are larger areally on platforms than in geosynclines. Explained at the same time is the spatial compensations of simultaneous uplifts with subsidences – a phenomenon observed in both geosynclines and platforms.

Some of the Archaean and all post-Archaean geosynclines feature a linear arrangement of their zones of uplift and downwarping (see Yu. M. Scheinmann's work [37] for ancient African geosynclines), with the same dominant tectonic trend often marking large geosynclinal areas of different ages. Such is the northwesterly trend prevailing between Sayan and the Apennines and expressed in the upper Proterozoic (Baikal) geosyncline of East Sayan; the Caledonian geosyncline of West Sayan and Gornyy Altai in the Hercynian geosyncline of Rudnyy Altai, in the Hercynian parageosyncline of Central Kazakhstan and Karatau, in the Alpine geosyncline of the Turkmen-Khorasan Mountains, Caucasus, Crimea, East Carpathians, Dinarids, and Apennines. Ancient platforms, on the other hand, are marked by rounded to irregular outlines of subgeanticlines and subgeosynclines, without linear arrangement.

The linear aspect of geosynclinal uplifts and subsidences can be explained as an effect of primary deep rifts [29, 49, 57]. A number of instances, already cited by the author [6], demonstrate that such rifts have a history of their own – that they originate at different times and provinces, and show different trends. Diagonal, northwest and northeast trends appear to prevail; although north-south and east-west trends are also present. We point out, for instance, that east-west Caledonian strike in western Central Kazakhstan had been replaced in the Hercynian by northwesterly trends of uplifts and subsidences, clearly related to the appearance of a new network of deep rifts. Scheinmann notes the intersection of Archaean geosynclines of different ages in Africa which may be connected with a reorientation of active deep rifts. However, the overall history of primary deep rifts is still little known.

Most diverse opinions have been voiced hitherto on the origin of primary deep rifts. In most instances, it is sought [36] in those stresses in the crust and mantle which may originate in the change in the magnitude of axial oblateness of the earth as the result of a

gradual slowing down in its rotation, braked up by tidal forces. No one has shown as yet, however, that a connection between deep rifts and stresses of that type does really exist.

Another explanation for the formation of deep rifts may be offered in the light of our concepts. Such rifts may be related to an expansion of the earth's interior as an effect of radioactive heat, with tensile stresses set up as a result, followed by fracturing of the upper layers. This conjecture, too, calls for an analysis of the possible distribution of stresses in the expanding mantle.

The fact that linear arrangement of tectonic zones is missing on ancient platforms indicates that primary deep rifts of that type cut through the geosynclinal level but do not penetrate to the platform level. Thus their usual penetration depth probably is 100 to 150 km. This, however, does not mean that other groups of deep rifts cannot be either deeper or shallower. On the other hand, the absence of linearity in some Archaean geosynclines (such as the Baltic Shield) with its predominately rounded to irregular granite domes) suggests that deep rifts have not yet originated there.

Examining the uplifts and troughs formed in geosynclines and on platforms as undulatory movements in the crust, we note that in some instances the uplifts have regular geometric forms (usually elongated-oval), while the troughs are subordinated to their form. In other instances, on the contrary, it is the troughs that have a definite form (usually rounded), with the uplifts distributed among them. Generally speaking, the first instance appears to prevail in geosynclines; the second, on ancient platforms.

When a lighter material is buoyed in the heavier one, while the latter sinks, the same two types of the form distribution are present in the ascending and descending currents. In some instances, lighter material forms either ascending columns or else ridges with definite geometric outlines, while the descending flows of heavier material fill up space between them. Conversely, heavier material forms reversed downward-growing columns and ridges, with the buoyed up lighter material filling up space between them. The less viscous material forms "shaped-up" columns and ridges, while the more viscous material flows between them.

On the basis of the predominant form of uplifts and troughs in geosynclines and ancient platforms, it can be stated that melted out light material in the geosynclinal level is not only lighter but also less viscous than the enclosing material. Deeper down, at the platform level, it is the heavier material coming in from above that has the lower viscosity. This somewhat unorthodox relationship between viscosities and densities requires special consideration. It indicates that on the platform level, the pressure increase with depth has a greater effect on the viscosity of material than on its density.

A long-noticed regularity prevails in the distribution of younger (Alpine) geosynclines over the globe. On one hand, these geosynclines girdle the Pacific; on the other hand, they extend approximately longitudinally from the Mediterranean across Central Asia, the Himalayas, and Indonesia. Earlier geosynclines also were present here but they were considerably broader and occupied an area far exceeding the present zones. Thus these zones should be regarded as the most favorable for a prolonged preservation of geosynclinal conditions.

A possible explanation is that conditions prevailing in these zones are most favorable for maintaining the activity of deep rifts which have promoted a continual melting, differentation, and vertical transfer of the mantle material. Reference is made here to W.H. Bucher's experiments [42] with paraffin spheres subjected to expansion from within. A system of fractures thus obtained at the surface of a sphere was fairly closely reminiscent of the distribution of younger geosynclines over the earth's surface. Paleogeographic reconstructions show that the Mediterranean-Himalayan-Alpine geosynclinal zone roughly corresponds to the Mesozoic and Lower Tertiary equator [31]. It is quite reasonable to suppose that centrifugal force, at its maximum at the equator, in turn promoted the opening of deep rifts and the rise of lighter material to the surface in the process of differentiation. This is another problem for quantitative study.

In the light of these concepts, it is rather improbable that a geosynclinal regimen could be fully revived in the most recent cooling stage for the upper mantle where platform conditions have set in. Theoretically, however, such an eventuality cannot be ruled out completely: the appearance of new deep rifts might disturb the mantle's equilibrium and lead to renewal of an intensive circulation of material in it – i.e., in those segments where a "material" potential has been preserved, i.e. where a local melting in the rift zone is still capable of bringing about differentiation. However, at an earlier stage of the earth's history, when even the upper mantle was involved in the heating, even such a phenomenon was quite probable in connection with the appearance of new melting hearths and with the increasing intricacy of the deep rift network. Could instances of intersecting geosynclines and their "regeneration," as cited by Scheinmann [37] for the Archaean, belong to that same ancient warming-up stage.

According to the data of absolute geochronology, a substantial break in crustal development

came about 1-1/2 billion years ago (in Fenno-Sarmathia, the transition from Karelian to Gothian). It was then that the first "stabilization cores" were formed in the crust with the subsequent enlargement of platforms and shrinking of geosynclines.[3] This compares well with Ye. A. Lyubimova's date for the onset of cooling in the upper mantle [37, p. 8].

The author's purpose being merely to set forth a most general outline of his concepts, this paper omits the many essential details in the development of deep-seated processes both in geosynclines and platforms. Those details are best considered in a separate work.

We turn now to the phenomenon of periodicity of tectogenesis, closely related to the development of geosynclines and platforms. As pointed out before, this periodicity is determined by general crustal oscillations whose amplitude is greater in geosynclines than on platforms. It has been observed that these general oscillations spread in time from geosynclines to the adjacent platforms, with both the general subsidence at the onset of a cycle and the general uplift at the close of its lagging somewhat on platforms as compared with geosynclines [3, 4]. We are inclined to regard this periodicity as somewhat similar to the behavior of the lid on a boiling kettle.

Radioactive heating and particularly fusing, lead to a volume expansion of the mantle material. It begins in geosynclines where the effect of deep rifts promotes fusing on a greater scale. As the temperature rises, the volume increase affects the adjacent regions. The melting and differentiation of mantle material become more intensive, and with it the vertical movement of material. This leads most of the heat to be conveyed to the mantle surface, inducing a temperature drop at depth and a corresponding reduction in volume – earlier and greater in geosynclines than on platforms. With this process terminated, a new concentration of heat takes place at depth, and the cycle is repeated.

The likelihood of such an interpretation for the causes of periodicity of tectogenesis is suggested by the sequence of the manifestations of igneous activity in geosynclines where a subsidence in the crust at the onset of a tectonic cycle follows magmatic eruptions of the close of the preceding cycle, i.e. the "terminal magmatic" stage which includes granite intrusions, invasion of fractures, and the terminal phase of surface flows, while a general uplift in the second half of the cycle is developed after the igneous activity has died down, prior to inversion.

Such an interpretation of the causes of periodicity of tectogenesis makes it possible to link general oscillations to undulatory movements; more specifically, it explains the sharper contrast between the two at the time of general uplift.

The rough synchronism of tectonic cycles on the global scale can be explained by the fact that the heating proceeds simultaneously throughout the generally chemically uniform mantle, while the cooling rapidly affects the entire mantle after the deep-seated, heated-up material has been buoyed up in many places. It is known, however, that this synchronism is not complete.

The expansion of the mantle material achieves more than just a surface uplift and an intensified circulation at depths. It may bring about fracturing in the upper mantle and crust, conducive to the formation of new deep rifts. The close of a tectonic cycle, marked by a general uplift, was just such a favorable time for a rejuvenation of the deep rift network. Indeed, new rifts did appear at the Caledonian-Hercynian boundary in Central Kazakhstan; and in Western Europe at the Hercynian-Alpine boundary.

This view of the periodicity of tectogenesis explains why the enlargement of platforms and the contraction of geosynclines takes place in "pushes" associated with the boundaries of tectonic cycles. More intense vertical circulation of the mantle material at the "terminal magmatic" stage leads to a considerable cooling of the upper mantle and when the cooling reaches a critical point, geosynclinal differentiation ceases. The fact that platforms, once formed, grow with each new tectonic push, taking in new areas, suggests that the mantle cooling process, having originated in a few places, spreads to involve ever larger areas.

Major tectonic cycles are complicated by cycles of lower and ever more localized orders which reflect the complex periodicity of the general crustal oscillations. That can be explained by the fact that the heating up of the mantle material, and its volume expansion, are disturbed by numerous minor shifts of this material, which convey some of the heat to the upper zones until finally the total concentration of heat would lead to a considerable shifting of material and a great loss of heat.

THE "BASALT" STAGE OF THE EARTH'S DEVELOPMENT

All phenoma discussed up to this point belong to that stage of the earth's development which is called "granitic." They are characterized by the formation of a granite crust.

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[3] Report of Academician A.A. Polkanov in the Session of the Section of Geologic-Geographic Sciences, AS USSR, February 2, 1960.

We do not go here into the formation process for this granite layer: it is best taken up elsewhere, in a detailed discussion of the development of geosynclines. Here, we only note that this process must now be considered in the light of the concept of granitization of sedimentary and metamorphic rocks and of the multiple remelting of earlier-formed granites as a result of action of "diamagmatic solutions," rich in silica, alkalis, and volatile components. Such solutions rise up from the mantle; their outflow stands in close relationship to the above-named differentiation in the upper mantle.

The granite stage is the first major stage in the development of the globe which can be studied by geologic methods. Should some earlier stages have existed, they lie beyond the scope of geology.

To be sure, the composition of the upper mantle during the granite stage was variable so long as lighter components could be melted out of it. Some acidic rocks and those of components which bring about granitization of the crust were separated out of eclogite under geosynclines by melting. Under the platforms where differentiation was still going on to a small extent intermediate and alkali rocks were melted out of the mantle; such rocks are known to be developed under platform conditions.

If we accept the ideas of Kennedy and Anderson on the two types of basalts — tholeite and olivine, with the first being differentiated into the calc-alkali series typical of geosynclines, and the second into an alkali series [50] - it may be assumed that the upper mantle material is altered from tholeite to olivine basalt as a result of geosynclinal differentiation.

The next stage in the development of the globe may be called "basaltic." It is marked by a mass rise of basalt to the surface and by a destruction of the granite crust, its surface expression is an array of phenomena briefly touched upon, above. Now we confirm their relation to the surfacing of basalt in more detail.

First of the phenomenon is post-platform activation, whose type, as stated above, is the Tien-Shan. The platform and parageosynclinal conditions established here locally as early as middle Paleozoic and elsewhere as beginning of the Mesozoic were replaced in the Neogene by extremely contrasting and intensive vertical crustal movements which led to the present dissected relief of that province. The distribution of zones of uplift and subsidence appears to have been determined by deep rifts of an early origin and were already present at the geosynclinal stage. They were rejuvenated in the activation, which explains the preservation of the ancient tectonic plan for the distribution of uplifts and troughs.

With regard to the direct causes of activation it is significant that deep seismic sounding in northern Tien-Shan has revealed the presence of basalt "roots" [14, 15, 16] underneath the activated uplifts, rather than of granites which hitherto have been found under geosynclinal uplifts. The crust under these uplifts turns out to be thickened because of a thicker basalt layer. Thus it can be surmised that post-platform activation is accompanied by melting out of unequal amounts of basalt from the mantle which "stuck" to the base of the crust.

Besides Tien-Shan, post-platform activation affects Gornyy Altai, West and East Sayan, the Baikal region, and Stanovoy Range. Lying south of there is the immense province of Central Asia, uplifted as a whole, especially in the Tibetan Plateau and its immediate vicinity. We assume that the thickening of the crust throughout Central Asia has been achieved through basalt melted out of deeper reaches.

Developed within the post-platform activation province are large troughs of the Baikal graben type. The numerous flows of basalt lava in those grabens are well known. However, a better understanding of such grabens comes from a quite different province - the East African graben system. Along their entire length, from the Dead Sea in the north to the Zambezi mouth in the south, these grabens are associated with a zone exhibiting unmistakable signs of activation, albeit somewhat different from those of Central Asia. As shown by H. Cloos, these grabens are located on two vast domal uplifts, mostly Tertiary, whose span exceeds that of standard platform subgeanticlines [44].

A recent geophysical study of the Red Sea graben has led R. Girdler to the belief that running along the axis of that immense graben is a considerably narrower (about 60 km) graben whose bottom is made up of basalts, obviously originated at depth and intruded in the crust as a huge dike, partially replacing the "granite" crust [46]. Other grabens in the East African system have not reached, as yet, the development stage of the Red Sea graben, and their subsidence is less. Therefore, there are no causes for assuming that their granite crust has been replaced by basalt; however, the latter is common in volcanic extrusives of these grabens. We do not mean to say that we ascribe the same origin to all grabens. We deal here with major downthrown grabens of a "planetary" order. Numerous minor grabens are formed as a result of fracturing and block subsidences in the uplift apexes, as described by Cloos and others [3, 44]. We believe, however, that this mechanism of gravity closing the tension fractures in the uplift arches cannot apply to grand-scale grabens.

We assign traprock volcanism known from the Siberian Platform, India, and Parana basin in South America to the group of phenomena

associated with the surfacing of basalt. Finally, the formation of oceans and the Mediterranean type seas is obviously related to the rise of basalts which, as we believe, break up and replace the granite crust and bring about the development of the surface basalt volcanism prevalent in the oceans.

The extreme variety of tectonic and igneous processes, related directly and indirectly to the rise of basalts from depths to the crust and to segments directly below it, necessitates a refinement in our terminology. The "basalt" stage, related to the greater importance of basalt in surface zones of the globe, includes the following phenomena:

a) tectonic activation to which we assign post-platform activation as expressed in a considerable intensification of oscillatory movements (as in Tien-Shan, Altai, East Africa) the formation of grabens and troughs of the Baikal and Trans-Baikal types, and the formation of high plateaus such as the Tibetan and the Pamirs;

b) mass flows of plateau-basalts on continents, with sill and dike intrusions by accompanying diabase and dolerites;

c) basaltization (basification) of the crust, already present in the formation of individual Red-Sea-type grabens but considerably more conspicuous in ocean-formation;

d) oceanization, expressed in the formation of oceans and mediterranean seas through destruction of the "granite" crust and its replacement by a basalt crust.

In studying the history of all those phenomena we shall see that the "basalt flood" came at different times for different places. It seems, however, that there is no evidence of such flows on a large scale prior to the close of the Paleozoic and the advent of the Mesozoic, when oceans came into existence, along with first traprocks on the platforms, and the typical Trans-Baikalian and Mongolian troughs. This process undoubtedly was intensified gradually, beginning with the Mesozoic, also in the Paleogene, and particularly in the Neogene with its flare-up of the post-platform activation, the formation of mediterranean seas and large grabens, and the considerable extension and deepening of the oceans. Thus the "basalt" stage set in after the granite one. However, inasmuch as the latter persisted in many places, the two stages somewhat overlap.

It should be made clear that we deal here not with any basalt flows but with plateau-like formations characterized by a specific and uniform chemical composition and by huge volumes of flow. Excluded are basic flows and intrusions of a normal geosynclinal development cycle marked by their much smaller volumes and by rapid changes to intermediate and acidic lavas. Such basalts appear to be related to the melting out of the upper mantle fusing zone, during a "granite" stage.

What is the explanation of this marshaling of basalt at depths and what is the mechanics of the bond between surface and deep-seated processes at that stage of our planet's development?

On the basis of her calculations, Lyubimova [19] concludes that, as deeper layers of the mantle warm while its upper reaches cool, the melting layer gradually sinks. However, its continuous sinking is hardly mandatory. It is possible to conceive of a new and independent melting layer appearing at a greater depth, in connection with the continuous concentration of heat at those depths which, as pointed out above, are endowed by considerable thermal autonomy. Such a new and deeper molten layer is formed simultaneously with the cooling of the upper mantle and the dampening of activity in the upper molten layer. As a result, the basalt stage occurs generally after geosynclinal conditions have been replaced at large by the platform That, however, does not always hold true: theoretically, " the surfacing of basalt" may take place while geosynclinal conditions still prevail at the surface.

We believe that precisely such a deep melting layer was the source of basalt in all of the above-named instances. The depth of its occurrence is conjectural. Its upper limit is extremely vague because of the evolution of the layer, of which more below. Its top is not likely to be above 400 km, at which depth we approach the upper melting layer. In determining its lower boundary we can take advantage of the maximum depth for earthquake foci (720 km) or else the base of the so-called Golitsin layer (layer "C" of the mantle) with its abrupt change in the acceleration rate for seismic waves, with depth (900 km). The first figure appears to be the more random, because not all deepest earthquakes have been recorded. We assume, accordingly, that the deep melting layer takes up all of the Golitsin layer (from 400 to 900 km). However, it must not be assumed that all of that layer goes to melt at once. It is rather more probable that the melting begins at its top and proceeds downward. It is also probable that, at any given instant, the melting is concentrated in small isolated hearths which, by shifting about, finally affect the entire layer. The simultaneous presence of limited molten hearths should have but little effect on the velocity of seismic waves which only pick up larger molten segments of the mantle.

A result of the heating and melting of material in the Golitsin layer is the volume increase, and tension in the upper mantle. This should be reflected in an extremely intensive fracturing of the upper mantle and the crust, as

well as in the appearance of a new series of rifts – this time deeper than those formed at the granite stage. These rifts provide avenues of escape for deep-seated and overheated basalts whose rise is determined by the density decrease for eclogites as they change to basalts, with volatiles generated within the latter.

It may be asked, at this point, why this deep melting is not accompanied by the same differentiation and the same selective melting-out of light components as occur in the melting of the upper layer? Why is it that only a very uniform basalt almost free of lighter melting products does rise up from the deeper layer?

That may be because the melting of material at such depths and under an immense confining pressure requires a very great temperature rise; under those conditions, material is highly superheated. Then, as the rifts open, it "boils up" and goes to melt all at once. In the upper layer the melting process may be more gradual.

Basalts originated at great depths rise up in columns considerable larger than those formed by material from the upper melting layer. That is because they have to overcome a considerably greater resistance of the overlying body. In their upper part, these basalt columns may split up into smaller columns and ridges, to accommodate themselves to the heterogeneous structure of the upper mantle and to the numerous rifts. This process is probably complicated by the fact that deep-seated basalts with their large stores of heat may fuse the surrounding material and assimilate it, in their upward progress.

As the deep-seated material progresses along the rifts toward the surface, an intensive vertical circulation originates in the upper mantle and the crust: the rise of superheated, gas-saturated substance is compensated for by an adjacent sinking of a cooler and therefore denser material – an already established constituent of the mantle and the crust.

The results of the rise of deep basalts are different, depending on permeability of the crust and its interaction with the basalts. Where the crust is readily fractured, it promotes plateau-basalt flows accompanied by some sagging of the crust above the sources of such flows. Examples of that have been observed, in the Tunguska basin of the Siberian Platform [28]. In other instances, the influx of basalt from below has led to a thickening of the crust and its uplift in ridges (Tien-Shan) or else in huge plateaus (Tibet and adjacent provinces).

Finally, in still other instances, superheated basalt reacts with the crust, destroys it, and replaces its granite layer. The chemism of this replacement is not quite clear; however, its fact is not to be doubted. V. V. Tikhomirov supposes the effect of metasomatic replacement [33].

A fusing and dissolution of the granite layer also are possible. Instances of such processes on a small scale have been described, to be sure, by Gorai, [47], Reynolds [54], and Turner and Verhoogen [58].

Whatever the replacement mechanism, there is always the question of change in the composition of the mantle as a result of "absorption" of the granite layer. Like the many other questions touched upon in this paper, this one requires special consideration. Still, a few general remarks can be made here on the subject.

The high temperatures of the intruding deep-seated basalts should cause the continental crust to melt, which will be reflected at the surface in the development of volcanism with a predominance of andesite lavas corresponding to an average composition of the continental crust. This is precisely the picture now observed along the Pacific periphery with its intensive melting of the continental crust brought about by superheated basalts rising up from the depths.

An important place among the products of volcanism belongs to water, whose content in granites reaches 7 percent. This water, along with that liberated directly from the rising basalts, fills up the simultaneously formed oceanic trough. Geochemists now agree on a deep-seated origin for oceanic water [30, 56]. According to Rubey [56], it was liberated in the crystallization of the granite crustal layer. It is probable, however, that large volumes of water are liberated in the melting of the crust, as well.

Other gaseous products of andesite volcanism, primarily carbon dioxide, escape into the atmosphere and affect its composition. Lavas and solid volcanic ejections undergo subaerial erosion, are broken up, and finally are redeposited as oceanic sediments, while salts leached out of volcanic rocks modify the chemical composition of oceanic waters.

It appears, then, that far from all of the granite layer is absorbed by the mantle material, to affect its composition. As to that granite material which is absorbed by the mantle, it becomes involved in a vertical circulation within the mantle and is sucked deep into the latter. The superheated deep basalt with gases generated in it obviously is less dense than the continental crust rocks; it is poured out over their surface. To compensate for this buoying up of basalts, the adjacent crustal blocks, along with those of the upper mantle, are dragged down by the descending currents; the final process of melting and dissolution of the granite layer involves quite large volumes

the mantle, probably exceeding many times e volume of granite. Thus the effect of this ocess on the average composition of the man- e may not be strong and may well fall into the nge of chemical differences between tholeite d olivine basalts, or oceanites.

As a result of the liberation of water and the latiles in the melting of the continental crust, ere is an increase in the average density of a lumn of solid material left behind after cool- g, at the melting place for the crust and below at, which leads to a subsidence of the solid ustal segment and to the formation of a marine oceanic trough. In that event, the Mohorovičić scontinuity will be found on a new level deter- ined by the depth of change from basalt to logite, in accordance with the new conditions temperature and pressure.

Isostatic conditions are not disturbed as the sult of all these transformations: instead of thick granite-basalt continental crust, there a thin water-basalt oceanic crust, with the logite substratum surface raised correspond- gly. The water layer participates in achiev- g an isostatic equilibrium, together and in the me capacity with solid layers of the crust and e mantle.

It may appear contradictory that the one and e same process - the rise of basalts - accounts r uplifts in the crust in activation, and for its nking in oceanization. The fact is that deep perheated basalt produces a crustal uplift ly until the crust resistance has been over- me. When basalt breaks through to the surface else replaces the granite layer, it constitutes excess load - after it cools off and with its latile components gone. As a result, the lid crust sags. In this interpretation, it is ite natural that each collapse (the formation a graben or a marine basin) should be pre- ded by an uplift. However, the latter may not me about because an ascending basalt current ay first pierce the crust and pour out over its rface.

An instance of continental crust being replaced the basalt is presented by the middle part of e Red Sea graben. Other grabens of the East rican system, still at an early stage of their velopment, do not exhibit such a phenomenon. may be assumed that their is the stage when sic rocks are intruding the crust from below, ereby rendering it somewhat heavier.

Instances of a granitic continental crust being placed by the basalt are presented by the Medi- rranean, Caribbean, Black, and Japanese seas, e south of the Caspian, and the Gulf of Mexico. e last two, as well as the Sea of Okhotsk, esent instances of an intermediate state, ere the continental crust has already become nner (20-25 km) without being fully replaced a basalt (oceanic crust). Seismic studies have shown that preserved in those instances are thick sequences of poorly consolidated sedimentary rocks (Gulf of Mexico, South Caspian) above a basalt layer [13, 53]; or else abnormally low velocities of seismic waves (7.4 km/sec in the Caribbean) occur directly above the Mohorovičić discontinuity; the latter phenomenon can be interpreted as a result of saturation of the upper eclogite interval by basalt which has come from the depths.

Finally, the outer members of this series are the oceans - immense provinces of the basification of the crust.

Oceans are the best witnesses to the fact that the rise of deep-seated basalts is related to the most intensive fracturing of the crust - and undoubtedly of the mantle, along with it. This fracturing is particularly conspicuous along the North Atlantic periphery, specifically in Scotland, one one side, and in Greenland on the other. It is well known that Scotland has been broken up by an array of long gaping fractures trending mostly north-south. The time of their formation coincides with the subsidence of the North Atlantic Ocean (Tertiary). These fractures served as flow channels for basalts typical of the Thule magmatic province which embraces all of the North Atlantic [58]. In Greenland fractures - also evidenced as basalt flow channels - break up the coastal flexure of Cretaceous and Eocene rocks [60]. According to seismic data, a thick basalt sheet (up to 3 km) covers the North Atlantic bottom [45].

It is not unlikely that the strong regional fracturing of Scandinavia as well as the intensive differentiation of Western Europe, present since the beginning of the Mesozoic when the main body of the Atlantic should have begun to form, are related to that event.

Along the Pacific periphery, intensive fracturing is present on the Chinese platform where it originated in the Cretaceous, along with the considerable enlargment and deepening of the Pacific [5]; as well as in California with its peculiar network of Tertiary faults.

The Pacific bottom is broken up by a huge number of faults. In the east, they are mostly east-west, trending northwesterly and partly northeastly in the center and the west. Associated with these diagonal rifts are chains of volcanic basalt islands and submarine ranges.

A conspicuous feature of the Indian Ocean zone of fracturing is the presence of the above-mentioned East African grabens.

It is fairly obvious that it is not the formation of oceans which brings about fracturing of the crust and mantle, but just the opposite. The oceans are associated with maximum fracturing in upper zones of the globe because it is this

fracturing that provides the avenues of escape for deep-seated basalts. The fracturing reflects the process of the general expansion of the earth, and the stretching of its mantle and crust, as a result of deep-seated radioactive heating. Evidence of the intensive fracturing in the vicinity of the oceans may indicate trends of a further extension of the oceanization process.

The origin of island arcs and their significance in the earth's history acquire new interest in the light of this concept. This topic, along with the asymmetry of the Pacific, is discussed in a paper written in cooperation with Ye. M. Rudich [9].

As we have pointed out before [2], the formation of oceans is associated with the beginning of the Mesozoic. Since then, they have broadened and deepened. Different segments of the World Ocean appear to be at different development stages. The North Atlantic is quite young, having subsided in the Neogene. Its depths are not great and the crust – while already devoid of its granite layer – is still fairly thick. Judging from seismic data, the upper three kilometers of the Norwegian Sea solid crust are made up of recently extruded basalts. Underlying them there is a 7-km-thick layer with intermediate velocities of seismic waves (7.5 km/sec), like the one identified underneath the Caribbean Sea [45, 53]. As in the Caribbean, we postulate here a zone of mixing for eclogite and basalt rising up from the depths. Judging from the situation in Scotland and Iceland, the subsidence took place here in the process of crushing of the continental crust, accompanied by mass outpourings of basalts with their subsequent absorption of granite blocks.

The South Atlantic and the Indian Oceans appear to be old. Here, the subsidence was accomplished in large blocks separated from one another by such grabens as those now developed in East Africa and which suggest the direction of further ocean expansion. Those oceans are deeper than the North Atlantic and the crust underneath them is typically oceanic.

The Pacific as a whole is probably still older yet. It is possible, however, that it merely has been deepening at a faster rate because of the particularly intensive fracturing of the mantle. It is deeper than the other oceans.

The passage from a shallower to a deeper ocean is accompanied by a shift toward more basic basalt lavas, in the direction of a higher basicity. Actually, in the North Atlantic, plateau-basalts alternate with tholeite basalts, in about the same proportion. In the Indian Ocean, plateau-basalts predominate. Present in the Pacific are the most basic varieties of basalts such as oceanites. This suggests that the progress of oceanization marshals ever deeper layers of the mantle, made up of ever more basic material – always staying, however within the basalt range of chemical composition. The fact that very deep mantle layers have been affected in the Pacific province is apparent from the depth of its earthquake foci, which attains 720 km. At the same time, the focal planes, generally dipping under the surrounding continents, constitute a boundary along which the most basic basalt rising up from the depths is brought in contact and interaction with the overlying material, immediately below the continents and apparently possessing a less basic composition. The belt of strongest earthquakes, including those with deep foci, which surround the Pacific, shows that the growth of the latter is most intensive at the present time. The fact that the Pacific is surrounded also by a volcanic belt, suggests a strong thermal action of the ascending superheated basalt on the surrounding crustal and mantle material, with the resulting melting-out of the latter, as indicated above. The intensification of the transformation process in the Pacific crust, as compared with other oceans, may have begun as early as the end of the Jurassic. The Pacific development is considered in more detail in the work cited above [9]. It should be emphasized that during more recent geologic time (Tertiary and Quaternary) the further oceanization in the Pacific has proceeded along its periphery, while in the Atlantic and Indian Oceans it has been concentrated in their axial parts, in a zone of median marine ridges (see below). This is undoubtedly reflected in different relationships of the Pacific on one hand and the Atlantic and Indian Oceans on the other, with their respective surrounding continents.

A stage in the formation of oceans is presented by the mediterranean type seas. We have pointed out that there is a similarity between the West Siberian Plain and the Piedmont plain (together with the Gulf plain), even to their age and the position with relation to Hercynian geosynclines. In this connection, an opinion has been voiced to the effect that the West Siberian Plain represents a sort of "oceanic failure" [2].

Oceans and mediterranean seas show a certain geometric pattern. In the light of the above it appears that this pattern has been determined by a lack of uniformity in the fracturing of an expanding earth and by the presence of preferential fracturing zones at the surface of a sphere under tension. It is quite probable that advantage has been taken of the primary heterogeneity of the globe, as well of those heterogeneities in the structure of the mantle and crust inherited from the preceding granite stage. Thus it probably is not an accident that the belt of newly formed seas from the Mediterranean through the Black Sea and on to the South Caspian, closely coincides with the Alpine geosyncline. It is of interest that located on the extension of that belt to the east,

:o Central and East Asia, is an immense ovince of tectonic activity of the crust; it is st as significant that this province widens into :riangle, eastward toward the Pacific.

Very characteristic for the oceans are sub-arine swells which occupy a median position the Atlantic and Indian Oceans. In the Pacific, ere is no such single median swell; there are stead numerous individual swells distributed oughout the ocean and trending, as pointed t above, chiefly to the northwest, with some rtheasterly trends also present.

Best known at the present time is the Mid-lantic swell. Seismic sounding has revealed considerable thickening of the basalt layer der it, and a basalt root, up to 30 km thick, netrating the underlying substratum. A study the swell surface has revealed the presence a graben running along its crest [45]. This aben undoubtedly suggests tensile stresses in cks, caused by the rising of the swell. On the ner hand, the depressed Mohorovičić discon-uity under it suggests that the swell corre-onds to a zone of ascending deep-seated ba-lts, which is at the same time the zone of an ditional upward heat flow; these two factors, gether, have brought about a deeper position the eclogite-basalt transition. Thus the nnection between the swell and a deep rift is questionable.

The Mid-Atlantic swell passes through Ice-nd where it encompasses a longitudinal upper ocene graben. That suggests a very young e for the entire swell.

The Mid-Indian swell branches off at Chagos and. One branch runs due north, with the ccan plateau-basalts located on its reaches. e other branch with its belt of earthquake epi-nters veers northwest, toward the Red Sea.

It should be noted that the Mid-Indian swell, e that of the North Atlantic, is located on a t which provided an avenue for ascending perheated basalts. This rift is the zone of ost intensive action of superheated basalts on crust, as witness the structure of the Red a where the continental crust along the swell s already been partly destroyed and basaltized th the formation of a graben. The latter's lationship to the submarine swell is the same for the Iceland graben and the Mid-Atlantic ell. The gravimetric picture in the Deccan teau province suggests that the downwarping the continental crust below some 4, 000 m of extruded basalt was accompanied by de-uction and thinning of that crust from below. is is the same course of basaltization which have observed for the North Atlantic.

Surface evidence of the upward flow of super-ated deep-seated basalts is present also in the nerous Pacific swells, with chains of volcanic islands along their axes. This concept of the nature of oceanic swells is in accord with the results of thermic measurements which show that the heat flow on swells at times is ten times the normal.[4]

Thus, in our interpretation, tectogenesis reflects the general trend in global development toward warming up by radioactive heat sources. The heat so accumulated is partially carried out by the melting-out and differentiation of the mantle material. The original melting-out takes place in the upper mantle. This corresponds to the first, the granite, tectogenetic stage with its geosyncline-platform development of the crust and undulatory oscillating movements. The crust is replenished with acid (granite) material.

Later on, melting affects a deeper layer of the mantle whence superheated basalt rises to the surface. This basalt stage is accompanied by tectonic activation and finally by destruction of the granite crust and by oceanization.

Thus, uplifts and downwarpings in the crust, developed in the process of its undulatory oscil-lations, on one hand, and the formation of ma-rine troughs of mediterranean (i. e. located on an oceanic crust) and oceanic types, on the other, represent different genetic processes. They are subject to different regularities and should be studied by different methods. An important difference between them is that the first type of movements is compensated for by accumu-lation of sediments and by erosion, while the second type remains uncompensated.

All these processes run uneven courses, both in space and time.

The lack of uniformity in time is expressed in the fact that melting-out does not affect all of the layer at once, but occurs in isolated hearths, at any given time, and involves the entire layer only gradually, in the process of their migration. Likewise the activation of individual deep rifts, which substantially affects the melting out process and the vertical circu-lation of the mantle material, is different at different times. Related to the lack of uniform-ity in the heat loss in the compound periodicity, or more precisely the intermittent nature of tectogenesis, whose manifestation is better known for the "granite" stage.

The lack of uniformity in space shows up in the fact that different segments of the earth's surface pass from one stage to another at dif-ferent times. Because of that, there always

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[4] Communication by Prof. Boullard at the Institute of the Physics of the Earth, Moscow, 1959.

are adjacent areas of different development stages. This determines the complexity and diversity in the crustal structure; on the other hand, if affords the means for reconstructing the history of the crustal development through a comparative study of its individual provinces.

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NEW DATA ON THE LOESS ROCKS OF CHINA[1]

by

Chang Tzung-hu[2]

REVIEWER'S NOTE

Discusses general loess types in China–divides into five types depending on occurrence and general physical characteristics. Discusses other characteristics such as densities, compaction, and soil horizons.

ABSTRACT

Loess and similar rocks of China occur in five distinct environments: 1) on the slopes of high and moderately high mountains, 2) in belts of weathered talus and coarse residual deposits in foothills, 3) on floors of intermontane basins, 4) in thick deposits on high plateaus, and 5) on valley terraces. Loess rocks are found in the following types of deposits: primary loess, weathered slump and talus, stream alluvium, and coarse eluvial deposits. Engineering characteristics of the loess differ depending on environment and type of deposit. Specific gravity ranges from 1.0 to 1.5, porosity is generally high but decreases at depth, permeability ranges widely, compaction capacity is greater in loesses of lower specific gravity. --M. Russell.

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INTRODUCTION

Loess and loess-like rock, called here loess rock for convenience, are widely developed over the Chinese People's Republic (CPR). Their comprehensive study is of great interest, both scientific and practical, not only for the CPR but also for countries where loess is widely developed: such study is helpful in solving the loess problem at large.

In recent years, in connection with the intensive development of industry and agriculture in northwestern provinces of China, where loess rocks occupy immense areas and are the thickest, their study has been carried on by a number of industrial and scientific-research organizations, including the Institute of Hydrogeology and Engineering Geology at the Ministry of Geology CPR.

As a result of these studies, new information has been gathered on the stratigraphy, material composition, and engineering-geologic properties of loess rocks, considerably adding to our knowledge of them. These studies are continuing but some preliminary conclusions are possible.

Some believe that loess rocks are spread in an unbroken mantle over only north China, while others claim that they occur in south China as well. This difference of opinion results from a different interpretation of the terms "loess" and "loess rock." Common yellow loam is often mistaken for true loess.

As a matter of fact, loess and loess-like rocks are found only north of the Tsinling Shan range. Here they cover most of Kansu and Shensi provinces and isolated areas of Honan, Shansi, and Hopeh provinces; they occur only occasionally in Tsinghai, Sinkiang, and Inner Mongolia.

It should be noted that in those areas where loess rocks form a solid cover, the highlands (Liu Panshan, Zuling, Yung Shan Liang ranges, etc.) are made up of hard rocks.

In their physiographic distribution, loess rocks can be divided into the following five locational groups: high and moderately high mountain areas, foothills, intermontane basins, plateaus, and river valleys.

Loess rocks of high to moderately high mountain areas occur only on mountain slopes up to 2000 m above sea level. They are usually only several meters thick. This type of loess rocks is characterized by poor sorting. Its silt content is lower than in other types: a coarse fraction (0.01-0.05 mm) makes up 40 percent with about 20 percent of a fine fraction (0.005-0.01 mm). There are occasional particles larger than 0.25 mm which are fragments of the country rocks below the loess. In their granulometric composition, loess rocks of this type belong to loess-like loams.

Loess rocks of the second type are found along the lower mountain slopes and in the transition zone from the mountains to foothill plains. They form a foothill belt a few to

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[1] Translated from Novyye dannyye o lessovykh porodakh Kitaya: Soviet Geology, No. 7, 1960, pp. 72-81.

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several tens of meters thick. They contain fractions coarser than 0. 25 mm. Their clay fraction is lower than in the first type and usually is less than 20 percent. These rocks belong to loess-like sandy loams and loams. They commonly overlie clastic material (sand, gravel, and pebble).

Loess rocks of this type have been observed in foothills of the Huo-Lan-Shan, T'a-Ch'ing-Shan, and east of the T'ai-Hang-Shan ranges, on the north slope of Nan-Shan, north and south slopes of Tien-Shan, and along the Shantung province highlands.

Loess rocks of the third type occur in intermontane basins, either blanketing them or only along their periphery. They are represented by weathered talus alluvium from a few to several tens of meters thick. Their silt content is usually more than 60 percent, with 20 percent or less of clay particles, thus marking them as loess-like sandy loams and loams. Loess rocks of this type have been observed in intermontane basins of the Liu Panshan range and Tsinghai province.

Most widely distributed are loess rocks of the fourth type, which blanket large areas of plateaus at altitudes of 1000 m above sea level and higher. Their thickness is incomparably greater than for the other types, attaining 250 m. Stratigraphically and lithologically they differ. These rocks exhibit several varied soil horizons. Granulometrically, they are loesses and loess-like loams, characterized by a high silt content and by the absence of particles coarser than 0. 25 mm. Their clay fraction (<0. 005 mm) is between 20 and 30 percent.

Belonging to type three [four?] are loesses and loess-like rocks in the Lung-Tung (east of the Liu Panshan Range) and Lung-Hsi (west of Liu-Pangshan) areas, and in northern Shensi.

Loess rocks of the fifth type are developed in river valleys. They are alluvial loess-like deposits constituting the upper part of river terraces. They are from a few to several tens of meters thick, locally attaining one hundred meters.

The composition of alluvial loess-like rocks differs from that of similar rocks of other types in having considerably higher content of the 0. 25-0. 05 mm fraction, up to 15 or 20 percent; the clay fraction accounts for from 5 to 20 percent.

Thus, a definite regularity prevails in the distribution of loess rocks over China. Certain features (stratification, thickness, lithology) are peculiar to each geologic-geographic division and these are dependent on their origin, which in turn is dependent on environment (geology and geography).

DATING AND CORRELATION

Stratigraphic differentiation and correlation of loess rocks in different regions is a controversial problem. Their stratigraphic section is different for different geologic-geographic regions. The thickest and most typical loess rock sections occur in that part of the loess plateau, east of the Liu-Panshan Range (the Lung-Tung area). Here, the loess sequence is divided into four stages. The youngest of them is redeposited Recent loess-like rocks of alluvium drift, and talus. Their thickness is extremely variable but small, on the whole.

The upper Quaternary loess stage (Q_{II}) has a maximum thickness of 100 m. Occurring in it are buried soils, forming 7 to 12 horizons which are developed almost everywhere in the Lung-Tung area. These buried soils occur not only in exposures of the upper loess intervals; they have been found in holes drilled in the water divide part of the plateau, near Changwu. That borehole reached basement rock.

Locally, several horizons of buried soils merge into one. For instance, the fifth buried-soil horizon north of Yungshan-Liang consists of three superposed levels with an overall thickness of 7 m. South of there, the third buried horizon consists of two strata about 4 m thick.

Underlying the upper Quaternary loess are reddish-yellow loess-like rocks of the second stage, which are middle Quaternary (Q_{II}). They are better consolidated and do not break up as readily as the overlying loess. Macroporous varieties are quite rare. The thickness of these rocks ranges from 60 to 70 m, occasionally reaching 100 m.

Still lower in the section are heavy loess-like loams and loess-like clays. They form the third loess-like stage, still better consolidated to actually hard. No buried soils have been observed among them. Their thickness is between 40 and 50 m.

In the west of the loess plateau, west of the Liu Panshan Range (Lunsi area), Recent redeposited loess-like rocks are mostly alluvial formations. Occurring in the interfluvial plateaus are mostly upper Quaternary loess deposits whose thickness has a wide range depending on relief, being greater on gentle slopes than on steep slopes. Unlike in the Lung-Tung area, buried soils, although present here, are developed locally rather than regionally as in the east.

Underlying the upper Quaternary loess in the Lung-Tung area are lower Quaternary red, loess-like, heavy loams and clays.

Along the middle course of the Huang-Ho in Shensi, Honan, and Shansi provinces, the constitution of the loess-like sequence is different. Here, upper Quaternary deposits are represented chiefly by alluvial and talus loesses and loess-like rocks, with their thickness ranging from ten to several tens of meters.

Middle Quaternary loess rocks are definitely weathered talus. Underlying them is coarse, poorly sorted material – gravel, sands, and clays – in lenses. Several buried soil horizons are present among these weathered talus formations. The overall loess thickness here is up to 100 m. Below that, there lie alluvial-lacustrine deposits of the so-called "San-men" series, presumably lower Quaternary. It is over 200 m thick.

Elsewhere, loess-like deposits are thin and occupy a subordinate position in the Quaternary section. Thus, in Shansi province, they cover the slopes of low to intermediate mountains, where they usually are less than 10 m thick. They are commonly underlain by heavy red loams are locally by a weathering crust of native rocks. In Sinkiang province, loess-like rocks form the upper part of a belt of weathered talus along the foothills, where they are but a few meters thick. The same is true for the west of Hopeh Province and Inner Mongolia.

It follows that the stratigraphy of loess deposits is different for different geologic-geographic regions of China and is determined by natural conditions of each area. It also should be noted that recent tectonic activity has played an important part in the accumulation of loess formation, although not to the same extent everywhere.

LITHOLOGY

The lithology of loess rocks of China is quite variable, depending on location and origin.

Table 1 shows that loess from the central Lung-Tung area contains a considerable amount of coarse silt particles (Mt. Hsi-Fung). North and away from the Liu Panshan Range, their percent content falls off, while that of the finely-sandy fraction increases. In the north of the Liu-Panshan, loess rocks are characterized by coarser fractions, larger than 0.25 mm. In Hsihsih and Tinghsih (Lung-Hsi area), they carry less of fine sand than in the Lung-Tung area; their clay content, on the other hand, is higher. It should be noted that Hsishih and Tingshih are located northwest of the center of the Lung-Tung area.

An increase in the percent content of fine sand is noticeable in alluvial loess-like rocks forming river terraces.

Loess rocks along the mountain slopes in the Tai-Yüan area have a quite different granulometric composition. The content of fraction less than 0.01 mm is considerably higher, here, while the coarse silt content is lower; the fine-sand fraction is higher.

TABLE 1

Area	Content in percent of fractions with diameters –					
	<0.25 mm	0.25-0.05 mm	0.05-0.01 mm	0.01-0.005 mm	0.005-0.002 mm	<0.002 mm
Lung-Tung (Kansu)						
Hsi-Fung	0	7	61-65	9	7	14
Pingliang	0	8-10	62-71		19-32	11-21
Huan-Hsiang	0	7-11	53-60	8-11	6-8	14-19
T'i-T'iao-Yüan.	0	17-32	54-61		3-6	10-21
Ning-Hsien Kuan	1.4	13	56	8	6-7	14
Lung-Hsi (Kansu)	0	5-8	55-61	9-12	6-10	17-19
Hsihsih	0	8-10	53-57	18-26		9-16
Wei-Ho valley (Shensi)	0	13-22	42-54	10-19	12-29	-
Shansi: T'ai-Yüan						
Hsi-Shan	0	10-19	52-55	11-18	13-18	
Tung-Shan	0	7-10	28-43	24-32		20-32
Honan						
Ling-Pao	0	10-33	51-77	5-17		7-21
San-Min	0	13	39	23		31
Shensi						
Ping-Lu	0	3-7	39-53	17-23		23-27

Note: Analysis was done by the pipette method, without removing the carbonates

Water-soluble salts, present in loess rocks, are represented by carbonates of calcium and magnesium, calcium sulfates, and sodium chlorites.

Table 2 shows that the content of $CaCO_3$ and $MgCO_3$ in loess rocks increases from the central Lung-Tung area toward the mountain range (Yung-shou and Pingliang mountains). This is not an accident, because the country rocks under the loess formation are rich in carbonates. Chemical analyses of sandstones and shales below the loess rocks show their $CaCO_3$ content as much as 39 percent and 4 percent $MgCO_3$. In carbonaceous shales it is 42 percent $CaCO_3$ and 30 percent $MgCO_3$. The content of Ca and Mg carbonates in loess rocks decreases toward river valleys. Alluvial loess-like rocks which form river terraces are usually characterized by a lower carbonate content.

The NaCl content in loess rocks is very low and differs from place to place and from horizon to horizon. It increases regularly toward the base of a loess formation. It is higher on higher (older) terraces and is reduced in lower terraces.

Almost everywhere present in loess rocks, although in amounts smaller than 0.1 percent, is $CaSO_4 \cdot 2H_2O$.

The percent of readily soluble salts in loess rocks is dependent chiefly on their origin: The content of these salts being lower in alluvial loess rocks than loess in drift; higher in the middle of interfluvial plateaus than in river valleys. The amount and composition of such salts reflect the physicochemical environment of the formation of loess rocks.

Quite common in loess rocks are rare and dispersed elements. Present along with such common elements as Al, Si, Ca, Na, Mg, K, and Fe, are Be, Pb, Mn, Ga, Ni, Ti, Cu, V, Zr, B, Co, Ba, Sr, Sc, Ag, Sb, and Sn. Analytic data show that loess-like rocks from different regions carry different amounts of different elements. This is of interest in connection with the problem of their origin. For instance, the Lung-Tung area loess contains more cobalt than loess of Shansi province; cobalt is missing in the Lunsi area loess. The zirconium content in loesses increases going toward Mt. Liu-Panshan but decreases north of the Lung-Tung area. That element is considerably less common in the Lunsi area loesses than in the Lung-Tung loesses.

Results of analyses for rocks underlying the loesses show that the above-named elements present in loess are also present in the underlying local rocks.

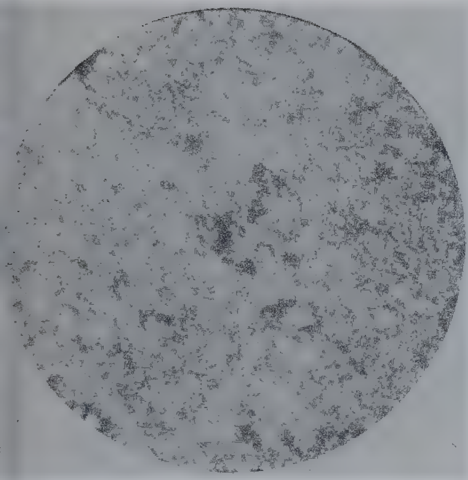
MINERALOGY

Study of the mineral composition of loess rocks of China is in its initial stage. The immersion method study of some loess samples from the Lung-Tung area has shown that from 50 to 70 percent of their coarser fraction consists of quartz, feldspars, and calcite, with 2 percent of rutile, sphene, ilmenite, leucoxene; other minerals are garnet, apatite, biotite, epidote, chlorite, magnetite, pyrite, limonite, and hornblende. Colloid fractions consist usually of clay minerals such as illite, which is the most common loess mineral, also kaolinite, montmorillonite, and glauconite. These last minerals are not everywhere present in loesses, or else are present in amounts considerably smaller than the former.

Microscopic study of loesses has revealed that their different genetic types differ substantially in their constitution and texture. In alluvial loesses, coarser grains (0.25-0.05 mm)

TABLE 2

Area and rock name	Content of water-soluble salts, in percent			
	$CaCO_3$	$MgCO_3$	$CaSO_4 \cdot 2H_2O$	NaCl
Hsi-Fung, loess	12-14	0.87-2.35	0.1	0.07-0.86
Ching-Yüan, loess	11-15	1.1 -2.5	0.1	-
Ning-Hsiang, loess	6-13	1.1 -1.4	0.1	0.08-0.12
Yung-Shou, loess	13-15	1.3 -1.6	0.1	0.46
Ping-Liang, loess	Locally up to 25	1.0 -1.8	0.1	0.28-0.86
Ping-Liang, (reddish loess-like, heavy loam)	38	26	-	-
Ting-Hsi, loess-like formations	9-12	-	0.2 -0.6	0.28-0.5
Lan-chou, loess-like loam	10-15	-	-	-
Yang-Ch'uo, loess-like loam	7	-	-	-
Ping-Lu, loess-like loam	9-11	0 -0.2	<0.1	<0.02
Shen-Hsien, loess-like loam	10-12	0.76-1.15	0.01-0.04 Locally up to 0.1	0.01-0.02



URE 1. Loess-like loam of alluvium (Q_{III}). X 70.

Ku Ching the upper Ching He valley.

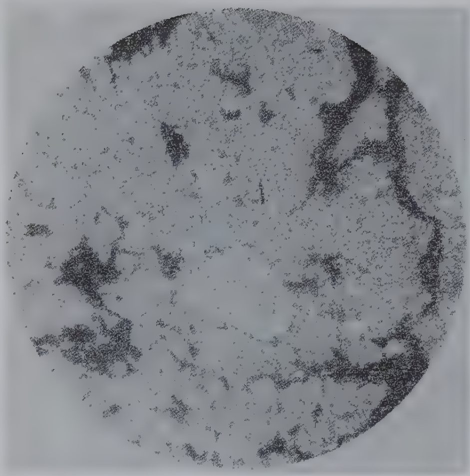
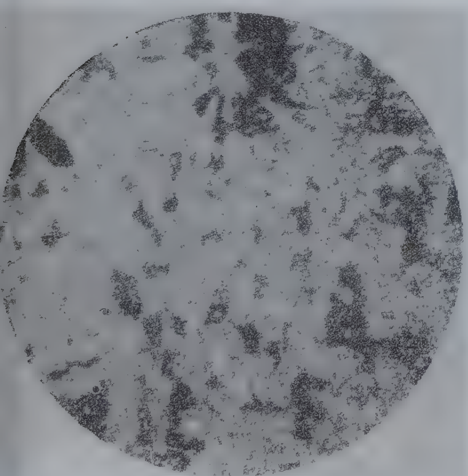


FIGURE 2. Elluvial loess-like loam (Q_{III-IV}). X 70.

East slope of Liu Panshan



URE 3. Loess-like loam of drift (Q_{III}). X 70.

East slope of Liu Panshan

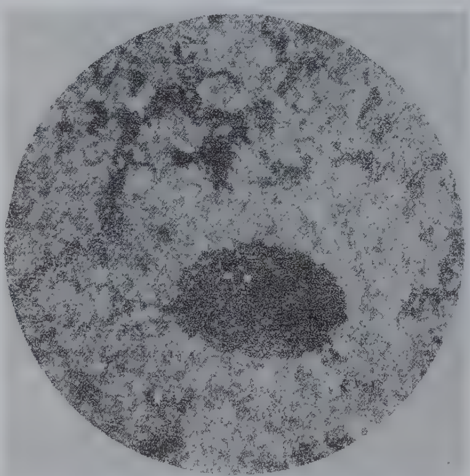


FIGURE 4. Loess of drift and weathered talus. (Q_{III}). X 70.

Mt. K'ai Pi-an alluvial

chiefly quartz, semi-rounded, and com- atively evenly distributed throughout the k. Voids are usualy small, with vague out- es (fig. 1).

Eluvial loess rocks have a quite different racter. Under the microscope, they show rser (>0.25 mm) fragments of intact native ks; their content of the 0.25-0.05 mm frac- is lower, and it is distributed in a ground-mass of fine material. Voids are large, angular, variable in form (fig. 2). The situation is different in deluvial loess rocks, where the groundmass consists chiefly of fine fractions, with a very few coarse grains. Voids vary as to their form and show clean-cut outlines (fig. 3).

Drift and weathered talus loess rocks have high porosity. Their voids are rounded to elliptical. The coarser grains (>0.05 mm) are

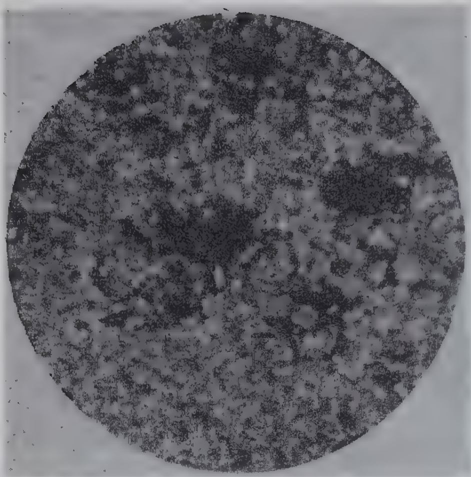


FIGURE 5. Loess of drift and weathered talus. (Q_{III}). X 70.

San Ch'a village

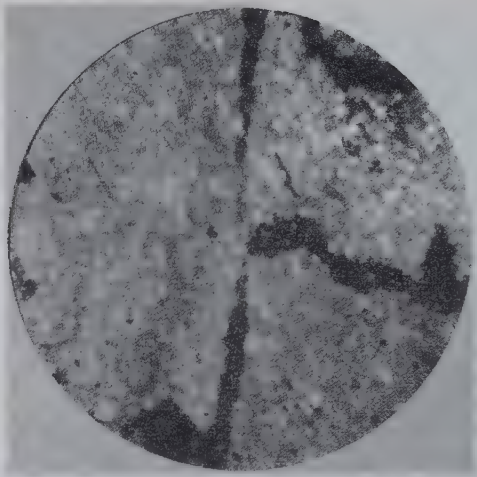


FIGURE 6. Loess-like loam (Q_I). X 70.

Chan Chiangtia village

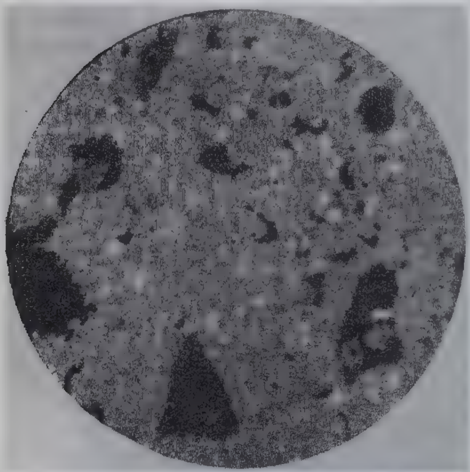


FIGURE 7. Heavy loess-like loam (Q_I). X 70.

Kai Pi-an village

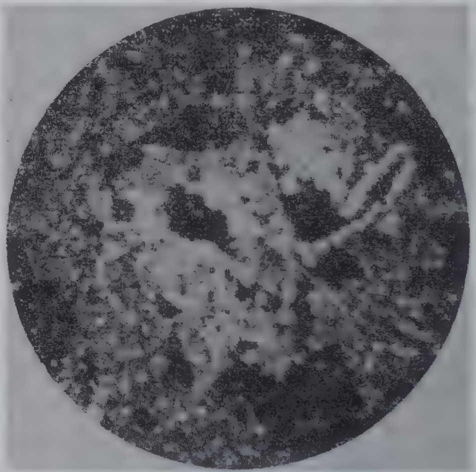


FIGURE 8. Buried soil (Q_{III}). X 70.

San-Ch'a village

mostly angular. Elongated fragments locally are oriented (figs. 4 and 5).

Middle and lower Quaternary loess-like rocks (Q_I and Q_{II}) differ sharply from the upper Quaternary in their angular voids, semi-rounded grains, their mutual arrangement, and their contact structure (figs. 6 and 7).

Buried soils have constitutions and textures of their own, not observed in loess rocks; in addition, they carry holes of plant roots (fig. 8).

ENGINEERING GEOLOGY OF LOESS

The most important engineering-geological properties of loess rocks are their specific gravity, porosity, water permeability, and compacting propensity.

Dry loess rocks from different regions have a different specific gravity. For loesses from

the central Lung-Tung area, it is from 1.32 to 1.37; for the Liu-Panshan Range foothill loesses (east slope), from 1.25 to 1.42; for those northwest of Hsifung from 1.20 to 1.39. Loess-like rocks in river terraces usually have a specific gravity of one, occasionally up to 1.4. The Lunsi area loess rocks are lighter than those from the Lung-Tung area, with a specific gravity of 1.12-1.25. Middle and lower Quaternary loesses are heavier (specific gravity up to 1.5).

Upper Quaternary loess rocks often show a high porosity, usually over 50 percent. On the other hand, middle and lower Quaternary loesses have a porosity usually less than 50 percent. No definite regularity in the porosity change for loess rocks has been determined, as yet, except that it decreases with depth.

Water permeability of loess rocks is different in different areas and horizons. From experimental field data, the filtration rate for upper Quaternary loesses varies from 0.6 to 0.8 m/day, with 0.8-1.2 m/day for the northwest of that area.

Buried soils occurring in loess are marked by an extremely low water-permeability, their filtration rate being 0.0004-0.0005 m/day. Loess-like rocks are practically water-tight.

A laboratory study of the compaction of loess rocks has shown that Chinese loesses are subject to compaction, the degree varying by area.

In the south of the Lung-Tung area (Yungshou), the relative compaction modulus (i_m) = 0.05-0.12 in the central part of that area, it is 0.05-0.14; its northwestern part, it is 0.02-0.06.

The compaction propensity is very strong in loess-like rocks from the Mt. Ping-Liang (near the Liu-Panshan Range), with i_m = 0.11-0.13. For instance, in Langshou, the Lung-Hsi area, alluvial loess-like rocks have i_m = 0.03-0.08. For the same rocks in Shansi province, i_m = 0.01-0.05.

In the west of the Honan Province the i_m for loess rocks varies from 0.06 to 0.14.

No direct connection has been observed between the compaction and other physical properties of loess rocks, except for specific gravity of dry ground. As a rule, light loess grounds are more compact. With their specific gravity of over 1.4, loess grounds undergo little if any compaction. Thus, the specific gravity of such rocks, comparatively readily determinable in the field, may serve as the simplest means of determining their compaction capacity.

These data on loess rocks of China lead to the following conclusions:

1) Loess rocks of China are divisible into five types, by the conditions of their occurrence: those of high to moderately high mountain provinces, foothill zone, intermontane basins, plateaus, and river valleys.

2) The origin of loess rocks is different in different geologic-geographic regions. Most common are weathered slump and talus, alluvial, eluvial and drift, and weathered talus coarse alluvial formations. One or more genetic types predominates in each region.[3]

3) Engineering-geological properties of loess rocks are quite diversified, depending on their origin and geologic-geographic conditions of the region.

4) The geologic-geographic loess rock types named above may constitute the basis for a regional engineering geological classification for loess rocks of China.

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[3] Plateau loess cannot be assigned to any of the author's types; its origin calls for a careful and comprehensive study. At the present time, loesses of that type are best regarded as problematical.--Russian editor.

STRATIGRAPHY FROM PALEOBOTANICAL DATA OF JURASSIC AND LOWER CRETACEOUS CONTINENTAL DEPOSITS IN EAST SIBERIA AND THE FAR EAST[1]

by

V. A. Vakhrameyev[2]

REVIEWER'S NOTE

Review of stratigraphy, correlations, and paleogeography of Jurassic and Lower Cretaceous of this large area. Continental plant-bearing beds are related to marine beds. Floral provinces recognized. Correlation charts. Many faunal and floral lists. Probably is of interest to Mesozoic stratigraphers and paleobotanists. Quite a good paper.

ABSTRACT

Lower and Middle Jurassic coal-bearing deposits occur in the western part of the region under consideration (the Irkutsk basin, the Trans-Baikalia depressions). Far to the east these are found only in the Upper Aldan basin. Upper Jurassic sediments are more widespread, occurring within the southern part of the Lena basin as well as in the Upper Aldan, Amur-Zeya and Bureya basins. The principal coal-forming stage dates back to the earlier Cretaceous; with this are associated most thick and productive strata of the Lena and Bureya basins as well as all coal-bearing strata of the Zyryansk, Suchansk and Suifansk basins. Age determinations of individual coal-bearing suites are chiefly based upon the study of plant remains and establishing leading paleofloristical complexes. At the present the complexes of the Upper Jurassic and Lower Cretaceous sediments are best known. The composition of one-age complexes varies with the movement from N to S conditioned by the then existing botanic-geographical zonality. --Auth. English summ.

* * *

Jurassic and Cretaceous continental coal-bearing deposits are widely distributed in East Siberia and the Far East. Study of their stratigraphy is of practical importance inasmuch as a number of major coal basins are associated with them.

Stratigraphic delineation, especially for age determination and regional correlations calls for careful study of paleobotanical assemblages of individual beds and horizons.

A primary goal is the correlation of continental sequences (if only in isolated sections) with their marine contemporaries. Then, it will be possible to establish changes in paleobotanical assemblages, in space as well as in time, and to attack the problem of differentiating botanico-geographic provinces of the Upper Mesozoic.

Direct correlation of the Jurassic and Lower Cretaceous floras of Central Asia with contemporaneous floras of Western Europe and southern parts of the U. S. S. R. has thus far not been possible because of the extreme peculiarity of Central Asian floras.

Fossil plants from Jurassic and Lower Cretaceous deposits of East Siberia and the Far East have been studied for many years by A. N. Krishtofovich [10] and V. D. Prinada [12-14]. It should be noted, however, that floras from the basins of rivers Amur and Bureya, as well as from Yakutia, now regarded mostly as Lower Cretaceous, were assigned by those students to Upper Jurassic and even Middle Jurassic. Jurassic and Lower Cretaceous floras and faunas from that area, and their significance in the stratigraphy of continental deposits, are being studied by N. D. Vasil'yevskaya [1-4], V. A. Vakrameyev [5-7], V. A. Samylina [15, 16] and B. M. Shtempel [18-19].

LOWER AND MIDDLE JURASSIC

In the Lower Jurassic, the sea penetrated into the Lena and Amur basins, the area under study, and as far west as the Trans-Baykal. The Middle Jurassic witnessed some sea regression, reflected in the drying out of isolated areas of the Lena coal basin and the Trans-Baykal. Maximum regression, however, occurred in the Upper Jurassic and Lower Cretaceous. Because of that, Lower and Middle Jurassic coal measures have been developed mostly west of this area – within the Irkutsk basin, and in small but numerous troughs of the Trans-Baykal region. Neither the fossil floras or faunas of the Irkutsk basin are well-known and so there is little agreement as to its age. Yu. P. Deyev [8] divides the coal measures in-

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[1]Translated from: Stratigrafiya yurskikh i nizhnezmelovykh kontinental'nykh otlozheniy vostochnoy Sibiri i dal'nego vostoka po dannym paleobotaniki: Soviet Geology, No. 7, 1960, pages 82-94.

[2]Geologic Institute of the Academy of Sciences of the U.S.S.R.

to the following three formations (oldest first): Zalarinsk, Cheremkhovka, and Sayan; he assigns them to Middle Jurassic. The Zalarinsk formation, at the base of the section, is a sandstone sequence devoid of identifiable fossils.

In the upper part of the Cheremkhovka formation is the well-known collection site for fossil plants and insects (Ust-Baley). According to O. M. Marynova (oral communication) the insects are most likely Middle Jurassic. The fossil Ust-Baley flora bears no clear evidence to either a Lower or Middle Jurassic age, according to V. D. Prinada. However, findings in other intervals of the Cheremkhovka formation of such forms as Neocalamites, Clathropteris, and Phlebopteris (oral communication by D. I. Yermolayev), along with a considerable content of Bennettites pollen in the spore-pollen assemblage of that formation (10-20 percent), as against the relatively small amount of the Coniopteris pollen, suggests that at least a portion of that formation is Lower Jurassic. The Sayan formation, assigned by almost all to the Middle Jurassic, carries many imprints of ferns Raphaelia diamensis and Coniopteris. The amount of Coniopteris spores increases sharply (55-70 percent) while the Bennettites pollen disappears almost completely.

To the east, in Yakutia and the Amur basin, the Lower and Middle Jurassic are represented by marine deposits; only in the Lena basin does the base of the Liassic carry the coarsely clastic Ukugut formation with a typical Liassic spore-pollen assemblage.

In that period, continental deposits were laid down in the Upper Aldan coal basin. Here, the Lower and Middle Jurassic include the Yukhta, Chylma, and Duraysk formations. The first one is made up mostly of mixed-grain sandstones interbedded with conglomerates resting on Cambrian and Precambrian deposits, and carries no identifiable plant remains. Coal beds occur in its upper part. The Chulma and Duraysk formations are represented by coal beds. The Duraysk formation carries a rather sparse fauna of Jurassic affinities represented by Raphaelia diamensis, a number of Coniopteris species, and numerous ginkgoes, podozamites, and Pytiophyllum.

UPPER JURASSIC

At that time, the sea regressed further, although minor local subsidences occurred (the Lean coal basin). On the whole, Upper Jurassic continental coal-bearing deposits are more widely distributed than the Middle and Lower Jurassic; more specifically, in the Lena and Amur-Zeya basins.

Upper Jurassic deposits in the southern Lena basin [5, 7] are represented by the Chechuma series with two formations – the coal-bearing Dzhaskoy (Callovian-Oxfordian) and the marine Sytoginsk (upper Oxfordian? – Lower Volgian). The Dzhaskoy formation is underlain by Bathonian marine deposits containing Cranocephalites and Arctocephalites. In the marginal part of the Lena basin, occupied by the Vilyuy trough, all of the Upper Jurassic consists of continental coal-bearing deposits. Northward, the Dzhaskoy continental deposits are replaced by marine, so that the marine Upper Jurassic, represented by all stages except for the Upper Volgian, is developed along the lower Lena.

Most typical of Upper Jurassic coal-bearing deposits in the Lena basin are the following fossil plant species: Raphaelia diamensis Sew., Cladophlebis aldanensis Vachr., C. serrulata Sam., Osmundopsis acutipinnula Vas., Heilungia aldanensis Sam., and a small-leaf Hausmannia.

Upper Jurassic continental deposits are developed also in the northeastern part of Asia. Identified in a coal-bearing member along the lower Omolon course (right tributary of Kolyma) was a small floral assemblage containing Cladophlebis aldanensis Vachr., previously identified as C. raciborskii Zeil., by M. F. Neyburg [11].

Designated as Upper Jarassic in the Upper Aldan basin may be the coal-bearing Gorkita formation with Raphaelia diamensis Sew. (very numerous), Cladophlebis aldanensis Vachr., Taeniopteris ex gr. vitrata Brong., etc. It should be noted that while Raphaelia diamensis is also characteristic of the Irkutsk and Upper Aldan Middle Jurassic, Cladophlebis aldanensis has been observed only in Upper Jurassic deposits although it has a wide areal distribution. In the East-Trans-Baykalian troughs, Upper Jurassic deposits are represented by an effusive tuffaceous deposit with very rare plant remains.

In the Bureya basin [17], the lower interval of the Upper Jurassic consists of Elgin marine deposits, with a Bathonian-Callovian fauna in their lower part, and an Oxfordian fauna (Modiola beds) in the middle. It is followed by the Chagan formation of dark shales, apparently littoral-marine, barren of identifiable fossils. The Chagan formation is overlain by a thick coal-bearing sequence subdivided into a number of formations. The lower Talyndzhan formation should be assigned to Upper Jurassic because it is characterized by a flora assemblage close to that from the Lena basin Upper Jurassic. V. D. Prinada and the author have identified the following in the Talyndzan formation: Hausmannia incisa Pryn., Coniopteris burejensis (Zal.) Sew., Eboracia kataevensis Vachr., Cladophlebis aldanensis Vachr., Clad. laxipinnata Pryn. Clad. orientalis Pryn., Clad. tongusorum Pryn., Raphaelia diamensis Sew., R. stricta Vachr., Sphenopteris samylinae Vachr., and assorted Pseudotorellia (Feildenia).

A correlation of Upper Jurassic plant assemblages from the Lena and Bureya basins shows that the Bureya assemblage contains a number of of new species unknown in the north (such as the very typical Cladophlebis laxipinnata).

Assigned to Upper Jurassic are the Ayak and Depsk formation from the Zeya River (left tributary of the Amur) with a like floral assemblage including Hausmannia incisa, Raphaelia diamensis, Cladophlebis aldanensis, and C. laxipinnata.

Judging by their occurrence (above a faunally characterized Oxfordian), the Talyndzhan and its contemporaneous Ayak and Deptsk formations must be assigned to the upper half of the Malm.

LOWER CRETACEOUS

The onset of Lower Cretaceous time was signaled by a Valanginian sea transgression in the lower Lena basin, large areas in the northeast of Asia, and the Maritime province with the lower courses of the Amur and Uda. However, after a comparatively short transgression, the sea retreated for good, persisting in the north only within the present day Arctic basin; and in the east – in the lower course of the Amur, in Kamchatka, Sakhalin, and the islands of Japan. This paleogeographic environment promoted the development of continental sedimentation, even more extensive in Lower Cretaceous time than in Lower Cretaceous time than in the Upper Jurassic.

The best known at the present time is the stratigraphy of the largest basin – the Lena – which is a good starting point for a survey of Lower Cretaceous deposits.

In the northern Lena basin (lower Lena), marine Valanginian deposits are overlain by a thick coal-bearing series differentiated into a number of formations. They are from oldest to youngest, the Kigilyakh, Kyusyur, Epi-Kyusyur, Bulun, Epi-Bulun, and Ogoner Yuryakh. The Kyusyur, Bulun, and Ogoner-Yuryakh formations are coal-bearing and carry a rich flora described by N. D. Vasilevskaya [1, 3]. The other formations are sandstone; with the exception of the Kigilyakh, they are barren of identifiable plant remains. Typical plant fossils of the Kyusyur formation are Coniopteris burejensis (Zal.) Sew., C. kolymensis (Pryn.), Vas., Cladophlebis lenaensis Vachr., and Aldania auriculata Sam.; of the Bulun formation – Coniopteris burejensis, rare Coniopteris onychioides Vas. et K.-M., Jacutiella amurensis (Nov.) Sam., assorted Ginkgo and Sphenobaiera; and of the Ogoner-Yuryakh, numerous Coniopteris, onychoides Adiantites gracilis Vas., Gleichenia lobata Vachr., Anomozamites arcticus Vas., Ginkgo adiantoides Ung. em Schap., Podozamites reinii Geyl., and Podozamites gramineus Heer.

Distributed in the lower Lena-Olenek watershed are desposits of the second half of the Lower Cretaceous represented by four formations. The lower two, the Lukumaysk and Uka, judging by their flora, are correlative with the Epi-Bulun and Ogoner-Yuryakh [9], while the upper two, the Meng-Yuryakh and Charchyk, are younger formations, as witness the Charchyk spore-pollen assemblage. Present here are isolated occurrences of angiosperm pollen, missing in the Ogoner-Yuryakh and Uka formations.

Overlying Lower Volgian marine deposits at the top of the Sytogin formation in the south of the Lena basin is a thick coal-bearing series divided into three formations: the Batylykh, Eksenyakh, and Khatyrykh [5, 7]. The Batylykh formation which carries the thickest and most numerous coal beds is characterized by a rich floral assemblage. Typical of its lower part a are Gonatosorus ketovae Vachr., Gonatosorus ketovae Vachr., Coniopteris burejensis (Zal.) Sew., C. nympharum Heer, C. setacea (Pryn.) Vachr., C. kolymensis (Pryn.), Cladophlebis lenaensis Vachr., Aldania auriculata Sam., Al. vachrameevi Sam., Pterophyllum burejense Pryn., Tyrmia polynovii (Nov.) Pryn. Occurring in the upper part are Gonatosorus ketovae Vachr., Coniopteris nympharum Heer, Cladophlebis sangarensis Vachr., and Jacutiella amurensis (Nov.) Sam. A correlation of these assemblages with those from Lower Cretaceous deposits in the north of the Lena basin shows that the same species are present in the Kyusyur and the lower half of the Batylykh formations; the Pulun formation, and the upper half of the Batylykh formation.

In recent years, N. D. Vasivevskaya [4] differentiated the Batylykh formation by paleobotanical data from the basins of rivers Lepiska (Lyampiska) and Chechuma (right tributaries of Lena) in the Sangar area, into the Yngyr and Chongurga formations. The Yngyr formation is characterized by the presence of almost all species noted above for the lower part of the Batylykh formation. Identified in the Chongurga formation are three horizons. The lower one carries Cladophlebis lenaensis Vachr., C. ambiqua Vas., C. decipiens Vas., Coniopteris burejensis (Zal.) Sew., Raphaelia prynadii Vachr; present in the middle one are Cladophlebis argutula Heer, Jacutiella amurensis (Novop.) Sam., etc; and in the upper – Cladophlebis sangarensis Vachr., Adiantites sp. and Ginkgo adiantoides Ung. We believe it more expedient, pending the tracing of the Yngyr and Chongurga formations throughout the Lena basin, to regard them as subformations of the Batylykh formation.

The Eksenyakh formation with its numerous Coniopteris onychioides Vas. et K.-M., Adiantiles aff. sewardi Tabe, Gleichenia lobata Vachr., Ginkgo adiontoides Ung., and Podozamites gramineus Heer, can be correlated

with the Ogoner-Yuryakh formation. Identified in addition in the Eksenyakh formation was Onychiopsis elongata Geyl., unknown from the Ogoner-Yuryakh formation. The Khatyrykh formation carries very few plant macrofossils, so that its correlation with the Charchyk formation is based on spore-pollen analysis, namely on the appearance of rare angiosperm pollen. It should be noted that none of the above-named typical plant species, (save for Onychiopsis elongata) occurs in Lower Cretaceous deposits of Western Europe and the southern U. S. S. R. They all are recently described local species. However, a correlation of the Lena basin northern section with these formations confirms their age as Lower Cretaceous.

On the basis of the distribution of these paleoflora assemblages in the latter, the Kyusyur and nature of changes in the latter, the Kyusyur and Balun formations, along with their contemporaneous Batylykh formation, can be assigned to the Neocomian; the Ogoner-Yuryakh, Lukumansk, Uka, and the correlative Eksenyakh formations – to the Aptian; and the Meng-Yuryakh, Charchyk, and the correlative Khatyryk formations – to the Albian.

The problem of the presence of the Upper Volgian equivalents in the south Lena basin section remains obscure. Upper Volgian marine deposits are missing in the northern part of that basin, with the Valanginian resting erosionally on various Upper Jurassic stages. Corresponding to the Upper Volgian stage in the south is either the top of the Sytogin formation or the base of the Yngyra. It should be noted that most of the latter is definitely Lower Cretaceous, correlative on the basis of plants with the Lower Cretaceous Kyusyur formation.

Probably the upper Volgian stage in the southern Lena basin is marked by a sedimentary break occurring after the Lower Volgian sea regression, as is the case in the north.

Lower Cretaceous coal measures are known from Kotel'nyy Island [2] and are widely developed east of the Verkhoyansk Range, within the Zyryansk basin, where they rest on a coal-free (Ozhogin) formation which in turn rests on marine Kimmeridgian and Lower Volgian deposits [12]. From among Lower Cretaceous deposits in the Zyryansk basin, the Sulyapsk formation – an analog of the Batylykh formation – can be identified from paleobotanical data. The most interesting member of that section is the overlying Buor-Kemyus formation cropping out along the Zyryanka river. Found in it along with typical Lower Cretaceous forms (Ruffordia goeppertii Dunk., Coniopteris onychioides Vas. et N.-M., etc.) have been numerous small-leaf angiosperms of genera Carex, Sassafras, Cercidiphyllum, Celastrophyllum, and Dalbergites.

The appearance of small-leaf angiosperms in Lower Cretaceous flora is typical of the Albian of Western Kazakhstan, Portugal, Western Canada, and the Atlantic coast of the United States. This makes it possible to assign the Buor-Kemyus formation to the Albian, by regarding it as contemporaneous with the Khatyryk and Charchyk formations barren of identifiable plant remains but carrying a spore-pollen assemblage where occasional angiosperm pollen appears among the standard Lower Cretaceous gymnosperm spores and pollen.

It was believed up to very recently that Mesozoic deposits in the Verkhoyansk basin are exclusively Jurassic; however, the latest paleobotanical studies have shown that the top of the Neryungrin ore deposit section (the Kholodnikansk formation) is Lower Cretaceous. Identified here were Cladophlebis cf. ketovae Vachr. and Coniopteris nympharum Heer. Coniopteris onychoides was collected from deposits in the adjacent Tokinsk trough.

Best known from the Amur basin are the Bureya basin Lower Cretaceous deposits, formerly assigned to Upper Jurassic by V. D. Prinada [13]. It was the study of the Lena basin floras, where their Lower Cretaceous age has been established by the correlation of coal measures with marine Valanginian, and then their correlation with the Bureya basin paleofloras, that demonstrated the presence of the Lower Cretaceous in the latter.

As noted before, the Talyndzhan formation, the lowest among the Bureya basin coal series, is still Upper Jurassic. It is overlain by the Urgal'sk formation, the richest in coal. Characteristic of that formation are Coniopteris burejensis (Zal.) Sew., C. nympharum Heer, C. saportana Heer, Dictyophyllum sp., Hausmannia leeiana Sze, Cladophlebis ex gr. lenaensis Vachr., C. novopokrovskii Pryn., Tyrmia polynovii (Novopokr.) Pryn., T. pterophylloides Pryn., assorted Nilsonnia gingkoes, and Podozamites. Over 60 species are known from the Urgal'sk formation.

Higher up there are the Chagdam and Chemchukin formations. Known chiefly from the latter are Coniopteris onychoides f. gracillis, C. nympharum Heer, Sphenopteris interstifolia Pryn., Disorus nimakanensis Vachr., Jacutiella amurensis (Nov.) Sam., Nilssonia schaumburgensis Dunk., and assorted ginkgoes and Podozamites. Still higher up there is the Iorek sandstone formation, barren of identifiable plant remains.

The Urgal'sk, Chagdam, and Chemchukin formations carry a number of species typical of the Batylykh and Eskenyakh formations, such as Cladophlebis ex gr. lenaensis, Coniopteris nympharum, C. onychioides, Jacutiella amurensis, and Tyrmia polynovii. However, these formations also contain a number of new endemic

species found so far only in the Amur basin. It should be stressed that such index Jurassic forms as Raphaelia diamensis and Cladiophlebis aldanensis, known from Upper Jurassic deposits of the Lena basin as well as from the Taldyzhansk formation of the Bureya basin, have not been found in the Urgal'sk and higher formations. It appears that the Urgal'sk, Chagdam, and Chemchukin formations should be assigned to the Neocomian and possibly Aptian.

The last area of a wide development of Lower Cretaceous continental deposits is the south Maritime Province with the Suchan and Suifun coal basins. Occurring at the base of the Suchan basin section, as they do in the north of the Lena basin, are the Aucella Valanginian beds, which suggests a Lower Cretaceous age of the overlying coal measures. The Suifun basin was not involved in the Valanginian transgression, so that coal measures rest here on an eroded surface of ancient granites, as well as on Triassic and Jurassic deposits.

Although the Lower Cretaceous floras of the Lena and Bureya basins contain relatively few species typical of European and Japanese deposits of the same age, the paleofloral assemblage from Lower Cretaceous deposits of the south Maritime province contains many European and Japanese forms [10, 18, 19]. Such forms are Onychiopsis elongata Geyl., Gleichenia cycadina (Schenk.), Adiantites sewardii Yabe, Weichselia reticulata Stock. et Webb., Phlebopteris dunkeri Schenk., and Cyparassidium gracile Heer. Present with them are local forms and a few forms common for the Maritime Province and the Lena and Bureya basins but missing in Europe. From among the above-named Lower Cretaceous index fossils of Europe and Japan, widely distributed in Lower Cretaceous coal measures of the south Maritime Province, only a few (Onyochiopsis elongata, Gleichenia cycadina) are known from the Bureya and Lena basins, where they occur in isolated imprints.

Small-leaf angiosperms, Aralia lucifera Kryscht. and Cissites prodromus, Krysht., appear in the upper part of the Suchan section, indicating an uppermost Cretaceous age for that interval.

Thus, Lower Cretaceous paleofloral assemblages from the Lena and Buryea basins of the South Maritime Province have but a few forms in common; in our opinion, that is due to a botanical-geographic zonation.

As early as Lower and Middle Cretaceous time, two botanical-geographic provinces were initiated in Eurasia [6, 7]: the Siberian and the one to the south, encompassing Western Europe, southern U. S. S. R., India, and South China. It may be designated as the Indo-European. Typical of the first province are the assorted ginkgoes, Podozamites, and conifers (of the Pityophyllum type); the second is characterized by the abundance of Cycadidiae and Bennetites, with Sphenobaiera, Phoenicopsis, and Czekanowskia either absent or quite rare; and by the presence of giant ferns and conifers with needle-like and scaly leaves (Araucarites, Pagiophyllum, Brachyphyllum).

The transition from one province to the other was gradual, in the Lower and Middle Jurassic. Sharper differences arose in the Upper Jurassic and were even more intensified in the Lower Cretaceous, in connection with a sharper differentiation of climatic zones.

During the Jurassic and Lower Cretaceous, Siberian vegetation developed gradually, under the then prevailing conditions of a temperate and humid climate which promoted intensive coal-making. Relicts preserved in Lower Cretaceous floras of Siberia render to them a Jurassic aspect.

Typical Upper Jurassic and Lower Cretaceous faunas of Siberia are the faunas of the Lena, Zuryansk, and Upper Aldan basins. Prominent in them are ginkgoes (Ginkgo, Ginkgodium, Baiera, Sphenobaiera, Czekanowskia, Phoenicopsis, Pseudotorellia) and conifers (Podozamites, Pityophyllum, less commonly Parataxodium, and Cephalotaxopsis), which formed the upper stage of vast forests. Prominent in the lower stage were ferns and some horsetails, with cycadophites less common.

Prominent among ferns were assorted Coniopteris and Cladophlebis, represented by tens of species; less common were Raphaelia, Gonatosorus, Hausmannia, Onychiopsis, Adiantites, and Gleichenia. Known from the Amur basin (river Bureya) are Dictyophyllum, Klukia, and various Eboracia. Giant ferns apparently did not grow in Siberia.

Of great interest are cycadophytes, most diversified in the south (basins of rivers Aldan and Amur). Present here along with the widely known genera Nilssonia, Taeniopteris, Anomozamites, Ctenis, and Pterophyllum, are such endemic forms as Jacutiella and Tyrmia (Bennettiales), Aldania and Heilungia (Cycadales), Bureja (Cycadophyta); with the exception of Tyrmia, they all are known only from Siberia.

The genera Zamites, Otozamites, Dictyozamites, and Pseudocycads, known from the south Maritime Province and Japan, are missing in Siberia. In the north (lower course of Lena) cycadophytes are less diversified. Lower Cretaceous floras of Siberia display a considerable similarity to the contemporaneous floras of Canada [20].

Upper Jurassic and Lower Cretaceous floras of the Bureya basin are similar to those of

iberia but contain a number of plants typical f the more southern Indo-European province erns Dictyophyllum, Klukia, Eboracia), as well s some species known only from the Amur asin, thus, allowing the designation of a special mur province within the Siberian.

Upper Jurassic and Lower Cretaceous faunas f the Maritime Province, Korea, Japan, and hina, should be assigned to the south (Indo-uropean) province. This is justified by the ict that Lower Cretaceous floras of the Mari-me Province and Japan are more similar to iose of Western Europe and the southern U.S.S.R. ian to the more proximate faunas of the Bureya id Lena basins.

In the light of these data, it would be inter-sting to consider the age of coal measures rom the northernmost regions of China, located the Amur and Sungari basins. These are the egan, Mulin, and Wokenhe basins. In Chinese eologic literature, coal measures of these asins (the Ilegan, Mulin, and Tsinsi formations) re usually regarded as Upper Jurassic. How-ver, a perusal of their fossil flora, together ith a collection assembled by Yu. B. Ustinov uring the joint Soviet-Chinese field work, and rocessed by the author, convincingly indicates Lower Cretaceous age for these deposits.

Present in these floras are such index species s Coniopteris naktogensis, C. onychioides Vas. K.-M., C. saportana Heer, Onychiopsis longata Geyl, Cladophlebis browniana (Dunk.) ew., Gleichenia cycadina (Schenk) Pryn., diantites sewardii Yabe. Almost all of them re typical of coal measures from the neighboring outh Maritime Province coal basins. A Lower retaceous age of these deposits is also sug-ested by their position above the Valanginian ucella beds. Some of these forms (Coniopteris nychioides, C. saportana) are known from the ureya basin Lower Cretaceous. No one has lentified in this assemblage such typical Upper urassic forms as Raphaelia diamensis and ladophlebis aldanensis, abundant in the Talynd-han formation of the Bureya basin, in the Ayak nd Depsk formations of the Zeya River and in ie Chechum series of the Lena basin.

As of now, there is a controversy between oviet and Chinese geologists as to the Jurassic-retaceous boundary in continental deposits. hinese paleobotanists [22], on the basis of ieir study of fossil floras, differentiate three eries within Jurassic continental deposits: the ictyophyllum-Clathopteris, the Coniopteris-hoenicopsis, and the Onychiopsis-Ruffordia. he first one they assign to the Rhaetian – near ie base of Lower Jurassic; the second, to the op of Lower Jurassic – Middle Jurassic; and the iird to Upper Jurassic and Lower Cretaceous. hus, they draw their Jurassic-Cretaceous oundary within the Onychiopsis-Ruffordia eries.

Their point of view is based on Japanese data. Identified in Japan is the Tetori group, assigned to Upper Jurassic, and the Lower Cretaceous Ryoseki group, underlain by marine deposits at the base of Lower Cretaceous (Torinosu lime-stones). Both formations carry very similar faunas; specifically Onychiopsis and Ruffordia are present in both. That allowed Japanese paleobotanists to designate the Onychiopsis-Ruffordia series which includes the two forma-tions.

While a Cretaceous age of the Ryoseki group is firmly established by the latter's position at the base of the Lower Cretaceous, an Upper Jurassic age of the entire Tetori group is far from certain. It should be noted, first of all, that the Tetori and Rydseki groups are located in different parts of Japan and have never been observed in the same section. Beds carrying plant remains and assigned to the Tetori group rest erosionally on marine deposits at the top of the Middle Jurassic and Callovian, and their relationship with Lower Cretaceous deposits remains obscure. It is quite possible, then, that all or some of the presumably Tetori beds with plant remains may be younger, i.e. Lower Cretaceous. Some Japanese geologists [21], too, assign the upper Tetori interval to Lower Creta-ceous.

If we assume an Upper Jurassic age for the Tetori beds with plant remains, it will be dif-fucult to explain the almost complete identity in specific plant assemblages for the Tetori and Ryoseki groups.

In the Soviet Union as well as in countries of Western Europe (England, France, Germany), genera Onyochiopsis and Ruffordia appear only in Lower Cretaceous deposits and are unknown from the Upper Jurassic. On the basis of all these data, it is more reasonable to draw the Jurassic-Cretaceous boundary in North China on the base of the Onychiopsis-Ruffordia series.

We believe that the Coniopteris-Phoenicopsis series, assigned to Middle Jurassic by Chinese geologists, belongs in fact to the middle and upper divisions of the Jurassic. Even now, Chinese paleobotanists propose to divide it into two parts. It should be noted that the upper half of this formation, in the western regions of China, carries red beds characteristic of Upper Jurassic deposits in the neighboring Ferghana. In addition, genus Coniopteris, after which this series is named, is just as widely developed in the Upper Jurassic deposits of the Soviet Union as it is in the Middle Jurassic. The same is true for genus Phoenicopsis.

* * *

The general sequence of various coal-making periods in East Siberia and the Far East is as follows (see table 1).

TABLE 1. Correlation chart for Jurassic and Lower Cretaceous deposits in East Siberia and the Far East

Age		Irkutsk basin	Lena basin: Northern part (lower courses of Lena and Olenek)	Lena basin: Southern part (lower courses of Aldan and Vilyuyka and middle course of Lena)	Zyryansk basin (middle course of Kolyma R.)	Upper Aldan basin (upper course of Aldan R.)	Bureya basin	Suchan basin (south Maritime Province)
Lower Cretaceous	Albian	Deposits unknown	Charchyk formation Meng-Yuryakh formation	Khatyryk formation	Buor-Kemyus formation	Deposits unknown	Deposits unknown	North-Suchan formation
	Aptian		Uka formation < Ogoner-Yuryakh formation Lukumaysk formation < Epi-Bulun formation	Eksenyakh formation	?		Iorek formation Chemchukin formation	Staro-Suchan formation
	Barremian		Bulun formation Epi-Kyusyur formation	Batylykh formation: Chongurga formation	Silyap formation		Chagdam formation	Lower Suchan formation
	Hauterivian		Kyusyur formation					
	Valanginian		Kigilyakh formation Aucella beds	Batylykh formation: Yngyr formation		Kholodnikansk formation	Ugral'sk formation	Aucella beds
Upper Jurassic	Upper Volgian			?	Ozhoginsk formation	Gorkitsk formation	Talyndzhan formation	Marine deposits
	Lower Volgian		Marine deposits	Sytogin formation				
	Kimmeridgian				Marine deposits		Chagan formation	
	Oxfordian			Dzhaskoy formation			Marine deposits	
	Callovian							
Middle Jurassic		Sayan formation Cheremkhov formation		Marine deposits		Duraysk formation Chul'makansk formation		
Lower Jurassic		Zalair formation				Yukhta formation		

Lower and Middle Jurassic coal measures are distributed in the western part of this area (Irkutsk basin and minor Trans-Baykalian troughs); to the east, coal measures of that age are present only in the Upper Aldan basin. Upper Jurassic coal measures have a somewhat wider distribution, being present in the south of the Lena basin, as well as in the Upper Aldan, Amur-Zeya, and Bureya basins.

Lower Cretaceous is the principal coal-making period. Related to that time is the formation of the thickest and most productive coal beds in the Lena and Bureya basins and the origin of the Zyryansk, Suchan, and Saifun coals. Here also belong coals of the Hegan, Mulin, and some other basins located on the left bank of the Amur, within the Chinese People's Republic.

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ABSOLUTE-AGE DETERMINATION OF SEDIMENTARY ROCKS BY GLAUCONITES[1]

by

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REVIEWER'S NOTE

This article gives some worthwhile stratigraphic "absolute-age" tiepoints which should be made available to English-speaking geologists.

ABSTRACT

An attempt is made to correlate absolute and relative geochronologies by using age determinations of glauconite which is syngenetic with the enclosing sediments. The data thus obtained for the Mesozoic-Cenozoic and lower Paleozoic - upper Proterozoic are considered most reliable and suggest great possibilities for the Ar-method. For the first time age values are obtained which range from 500 to 1, 300 million years for the oldest sedimentary formations within the Russian platform, Urals and East Siberia. -Auth. English Summ.

* * *

INTRODUCTION

Until recently, the duration of geologic events in the history of the earth was estimated mostly by determining the age of minerals from intrusive rocks. That led to some uncertainties, even when the lower age boundary of an intrusion could be determined fairly accurately from the faunally characterized sedimentary rocks which it cuts. As a rule, its upper age boundary, as determined from the occurrence of the intrusion pebbles in the overlying sediments, was by no means always accurate, inasmuch as it could have been separated by a considerable time interval from the "instant" of the intrusion. Thus the absolute dating of geologic formations by means of intrusive rocks is but an approximation of time intervals between individual stages and phases of igneous activity. For these reasons, it is very desirable to correlate absolute geochronology with the conventional biostratigraphic scale by determining the absolute age of those formations carrying fossils.

Such a correlation became possible with the development of the argon method, using authigenic glauconite syngenetic with sedimentary sequences whose ages are known from biostratigraphic data.

The wide distribution of glauconites in time and space, together with the fact that they are contemporaneous with marine deposits of the same diagenesis, opens up concrete possibilities of determining the age of sedimentary rocks by the argon method, from their contained glauconite.

Relatively few Soviet and foreign works deal with the absolute-age determination of glauconite by the argon method [1, 2, 4, 6, 7, 8, 10, 11]. The first attempt at determining the age of glauconites by the strontium method was made by R. F. Cormier, L. F. Herzog, W. H. Pinson, and R. M. Hurley [9]. The data published suggest that it is possible to obtain reliable age figures on glauconite. There still is some doubt, however, as to their reliability, as the results of systematic studies of the preservation of radiogenic argon in glauconite are contradictory. Furthermore, in determining the age of some specimens, a number of authors have obtained obviously unsatisfactory, yet unexplained results.

In structure, glauconites are very close to micas; by analogy with the latter, they should preserve radiogenic argon well. However, Kh. I. Amirkhanov, S. B. Brandt, et al. [3], in their study of argon loss from glauconite, through heating, have recorded considerable argon loss (as much as 25 percent) at temperatures as low as 100 to 200°C, which they ascribed to desorption. That has led to the assumption of a poor preservation of radiogenic argon in glauconite.

We repeated the experiments of those authors and studied the argon loss from glauconite during heating. Grains of different sizes were used (from larger than 0. 25 mm to smaller than 0. 01 mm). We did not observe any argon loss in heating the glauconite to 100-200°C. We believe that the results of their experiments were affected by errors in method, and so were their conclusions.

The four curves which we have obtained for as many samples show that argon loss begins virtually simultaneously with liberation of the water of composition; liberation of adsorbed water is not accompanied by loss of argon. It

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[1] Translated from Opredeleniye absolyutnogo vozrasta osadochnykh porod po glaukonitam: Sovetskaya Geologiya, 1960, no.7, pp.103-115.

[2] All-Union Geological Institute (VSEGEI)

also is significant that the size of glauconite grains does not affect the argon liberation process. All this leads us to believe that loss of radiogenic argon from glauconite takes place only during destruction of the crystalline lattice and is not related to desorption. Consequently, in the absence of such lattice-destroying processes, good preservation of argon in glauconites can be expected during long stretches of geologic time.

The mobility of argon is not the only possible cause of changes in the Ar^{40}/K^{40} ratio in glauconites. The adsorptive propensity of glauconite and its definite tendency for cation exchange are known to determine great fluctuations in its chemical composition. That induced us to study the cation exchange reaction in glauconite and to evaluate its effect on the potassium content and on the preservation of radiogenic argon. If this reaction is not merely external but affects the lattice ions, it may be a cause of argon loss. The difficulty of timing such reactions in nature might constitute a serious hindrance in obtaining reliable absolute age figures on glauconite.

Our studies in this field have just begun and so they deal with but a few variations in the experimental conditions, and with only a few glauconite samples; the results so obtained should be regarded as preliminary. The experiments were set up on three pure samples of a dark green variety of glauconite. The cation exchange reaction was carried out by standard method [5] at room temperature. A weighed glauconite sample was processed first by hydrochloric acid of a definite concentration, then by KCl and $CaCl_2$ solutions, until complete saturation by the corresponding cations had been achieved. The solution concentration varied from 0.05 to 0.5n. As a result of the processing of glauconites with solutions of appropriate cations, they were changed consecutively to H-form, K-form, and Ca-form. The content of potassium and argon was determined in both the original material and its Ca-form. In addition, the potassium content was determined in K-form of the glauconite. The results so obtained (table 1) show that the argon content in processed glauconite samples remained unchanged within experimental error. This suggests that potassium in the glauconite crystalline lattice does not participiate in cation exchange.

Given in Table 2 is the potassium content in glauconite samples at various stages of their processing. It gives an idea of changes related to K-adsorption by the mineral from solution. Under our experimental conditions, the amount of potassium adsorbed was up to 13 percent of its total content in glauconite.

In this connection, it was of interest to determine the probability of the presence of appreciable amounts of adsorbed potassium in glauconite. That was done for a series of glauconite samples, before and after their processing with 0.05 n solution of HCl (table 3).

As shown in Table 3, changes in the potassium content of glauconites with different adsorptive capacities are either small or altogether absent, so that corrections in the age figures will be insignificant.

However, this problem cannot be regarded as definitely solved: judging from our data, we cannot categorically reject the possibility that adsorbed potassium is present in glauconite. Now, the theory of cation exchange implies the presence of a relative rather than absolute value of the exchange capacity, depending on the medium, the concentration and pH of solutions, and other factors.

In like manner, we believe it improbable that glauconite contains excess argon captured in the process of mineral formation. A distortion in the Ar^{40}/K^{40} ratio may take place when glauconite is not completely free of a potassium-carrying terrigenous addition. In that event, the age determination error for glauconite will increase with the age difference between it and the material added. With this in mind, we analysed not only the isolated pure glauconite but the rock as a whole. Preliminary data (table 4) show a perceptible distortion in the age determining ratio Ar^{40}/K^{40} only in a sample with feldspar impurities. Thus the purity of glauconite used in analysis is a prerequisite for reliable age figures. Our study shows glauconite to be quite suitable for absolute dating. However, these investigations did not take into account all of the possible factors affecting the Ar^{40}/K^{40} ratio in glauconite under natural conditions, and so we cannot be sure of the accuracy of every age figure.

With the assistance of many geologists, a large collection of glauconite-bearing rock specimens was made up, representing a composite section of almost all geologic formations, from upper Proterozoic to upper Paleogene. The glauconite samples (about 100) were taken from sedimentary rocks mostly reliably dated biostratigraphically. Some of them came from stratigraphic drilling tests; the rest, from outcrops. These glauconite samples differed from one another, to a considerable extent, both in appearance and composition. Among samples analysed there were varieties of all colors, from dark-olive-green to pale green. Their grain size was just as variable (from 1mm to pelitic).

The age of glauconite was determined by the argon method. Potassium was determined by the dipicrylaminate method with a preliminary decomposition of the sample by a mixture of fluoric and sulfuric acid. Argon was measured by the volumentric method, its radiogenic purity checked by mass spectrometer.

TABLE 1

Sample	Concentration of reactive solutions	Amount of HCl absorbed in mg-eqv. to 100 g glauconite	K-content, percent		Argon content cm^3/g	
			Before processing	After processing	Before processing	After processing
186-c	0.05 n	19	5.70	5.60	0.246	0.242
1	0.1 n	22	6.06	5.75	0.170	0.170
B	0.1 n	36	6.65	6.55	1.349	1.350
186-c	0.5 n	22	5.70	5.78	0.246	0.242

TABLE 2

Sample	Content of K, percent				Content of exchange K, relative percent
	Before processing	H-form	K-form	Ca-form	
B	6.06	5.75	6.50	5.75	13
1	6.65	6.50	7.0	6.55	7.5

TABLE 3

Sample location	Age in million years	K-content, percent		Relative change in K-content, percent	Adsorptive capacity of glauconite, mg-eqv. to 100 g glauconite
		Before processing	After processing		
Cis-Caucasus, borehole No. 1, Umantsevo	37	5.31	5.31	0	4
Czechoslovakia Coberjik (A)	76	5.60	5.63	+0.5	20
Czechoslovakia Coberjik (B)	77	6.06	5.75	-5.2	36
Kaluzhskaya Bukan'sk deposit	80	5.78	5.77	-0.2	12
Geogia, r. Ingur	90	5.68	5.74	+1.0	12
Caucasus, r. Bol'shaya Laba, Skryleyeva ravine	105	5.72	5.63	-1.9	12
Estonia, deposit Maardu I	467	6.65	6.55	-1.5	22
China, Hopeh Province, 186-c	890	5.70	5.68	-0.3	19

TABLE 4

Sample	Sampling location	K (in percent)	$Ar^{40} 10^{-7}$ g/g	$\frac{Ar^{40}}{K^{40}}$	Age in million years	Remarks
Glauconite	River Belaya, Caucasus	6.35	0.407	0.0053	93	Impurities mostly quartz
Sandstone with glauconite	River Belaya, Caucasus	4.52	0.260	0.0049	86	
Glauconite	Serdobsk test No. 2-R	6.12	3.84	0.0511	749	Impurities mostly feldspar
Sandstone with glauconite	Serdobsk test No. 2-R	2.88	2.43	0.0700	964	

TABLE 5

Period	Epoch	Glauconite sampling locations	Rocks	K, percent	$\frac{Ar^{40}}{K^{40}}$	Age in million years	Geologic age	Data by other authors
Neogene	Miocene	-	-	-	-	-	-	22-27[1] 18-32[11,12]
Paleogene	Oligocene	-	-	-	-	-	-	33[1]
	Eocene	Cis-Caucasus, Umantsevo No. 54, 310 m (Caucasian Joint Expedition)	Sandstone	5.31	0.0021	37	Kiev stage	-
		Volga region, Stalingrad test No. 4077, 119 m, (Caucasian Joint Expedition)	Argillaceous sandstone	5.48	0.0026	46	-	43-64[1], 48[13], 60[9], 34[11,12]
		Turgao(B.Mikhaylov)	Sandstone	4.99	0.0029	51	Tassaran fm., middle Eocene	-
	Paleocene	Abkhazia, r. Kodor, (G. A. Kazakov)	Limestone	6.99	0.0030	53	Top of Paleocene	44[11]
Cretaceous	Upper	Daghestan, Ullu-Chay (Kazakov)	-	4.62	0.0038	70	Danian	-
		Volga region, Saratov, Mt. Lysaya (L. Kornetova)	Marl	6.02	0.0045	79	Senonian	76-78[1]
		-	-	-	-	-	Coniacian	89[1]
		Czechoslovakia, Coberjik, borehole 77-78 m (Brezina)	Sandstone	5.96 6.00	0.0044 0.0045	78 79	Cenomanian	94[8], 70[13] 62-70[9]
		Czechoslovakia, Melnyk area, Koshatka deposit (M. Mashka)		4.42	0.0053	93		-
		Kaluzhskaya, Bukan'sk deposit, (B.N.Himmelfarb)	Sands	5.78	0.0045	80		-
		No. Caucasus, Bol'shaya Laba R. Skryleyeva ravine (G. A. Kazakov)	Siltstone	4.29	0.0057	100	Albian	89-100[1]
			Argillaceous sandstone	5.72	0.0059	103	Aptian	-
		No. Caucasus, Belaya R. (G. A. Kazakov)		6.35	0.0053	93		100-139 [1]
		No. Caucasus, Baksan R. (G.A. Kazakov)	Siltstone	5.00	0.0061	107		130[11,12]
	Lower	Gruziya, Ingur R. (G. A. Kazakov)	Limestone	5.68	0.0053	93	Barremian	100[1]
		Moscow, Lenin Mts. (G. A. Kazakov)	Sandstone	5.28	0.0053	93	Neocomian	-
Jurassic	Upper	Moscow area, Yegor'tevsk deposit, from a borehole (Ts. I. Uflyand)	Argillaceous sandstone	5.23 4.91	0.0079 0.0077	136 133	Tithonian (subphosphorite beds)	145[1]

NOTE: All data by Russian authors have been converted to new figures for the potassium decay constants $\lambda k = 0.557 \cdot 10^{-10}$ years^{-1} and $\lambda\beta = 4.72 \cdot 10^{10}$ years^{-1}.

The following potassium decay constants were used in the age computations:

$$\lambda_k = 0.557 \times 10^{-10} \text{ years}^{-1}$$
and
$$\lambda_\beta = 4.72 \times 10^{-10} \text{ years}^{-1}$$

The selection of material, its mineralogical study, and separation of monomineral fractions were done in the Institute of Geochemistry and Analytic Chemistry, Academy of Sciences, U.S.S.R. (Moscow), by G. A. Kazakov. All experimental work of the absolute age determination was done by the authors at the All-Union Geological Institute (VSEGEI) (Leningrad), in cooperation with V. D. Sprintsson and L. V. Shashukova.

CENOZOIC AND MESOZOIC

Well-matched figures were obtained for a number of Tertiary and Cretaceous glauconite samples. Table 5 shows a somewhat greater scattering of age figures for Lower Cretaceous glauconites. These preliminary data suggest an age interval of 60-70 million years (m. y.) for the Mesozoic-Cenozoic boundary, and about 135 m. y. for the Jurassic-Cretaceous boundary. These results compare well with those of other authors and fit the Holmes scale. However, additional data are required for dating the boundaries of divisions of the Cenozoic and Mesozoic. The work in this field is in progress, on glauconite samples for the Mesozoic-Cenozoic of the Russian and Siberian Platforms, Turgai, Caucasus, and Central Asia.

UPPER TO MIDDLE PALEOZOIC

The stretch of geologic time from 150 m. y. to 400 m. y., i. e. from middle Mesozoic to lower Paleozoic, has not been adequately studied as yet. Data obtained on a small number of glauconite samples (see table 6) are not in a satisfactory agreement with the approximate scale of geologic time and call for further refinement. It becomes clear, however, that the age boundaries for divisions of the Paleozoic will have to be lowered considerably with relation to the Holmes scale.

TABLE 6

Glauconite sampling location	K, percent	$\frac{Ar^{40}}{K^{40}}$	Absolute age, million years	Geologic age
No. Timan, Indiga R. (V. P. Barkhatova)	4.62	0.0164	274	Lower Permian, Sakmarian stage
Dergunovka borehole, depth 1822 m	5.29	0.0186	308	Middle Carboniferous, Moscovian stage
Voronezh massif, north slope, village Lezhen'ki	6.78	0.0206	335	Vereya horizon Upper Devonian, Frasnian stage, Voronezh beds

Recently we have received many glauconite samples, well dated paleontologically (from Upper Permian to Ordovician), and the work of determining the upper and middle Paleozoic boundaries is continuing.

LOWER PALEOZOIC - UPPER PROTEROZOIC

Estimating geologic time and correlating sedimentary sequences becomes considerably more difficult as we descend below the "Olenellus biozone," because the correlation method by spores, algae, worms, and stromatolites has not as yet been adequately worked out.

We believe that the data obtained on glauconite samples from the most ancient sedimentary formations of the U. S. S. R. are especially interesting and deserving of additional study. We have succeeded in obtaining a unique collection of glauconite samples from outcrops and drilled test holes. The age data have already been obtained for some areas, for intervals ranging from the Ordovician through the upper Proterozoic. These results are considered separately for each area.

RUSSIAN PLATFORM

Table 7 presents results of the absolute age determination for glauconite samples from Ordovician, Lower Cambrian, and the most ancient sedimentary rocks of the Russian Platform. The absolute age figures are faunally characterized Lower Ordovician (Tremadoc, Arenig?) turned out to be very close, varying in the range of from 460 to 470 million years.

Extremely important is the confirmation by the argon method on glauconite of a break between Lower Ordovician and Lower Cambrian, which has been noted from the study of well cuttings and cores from test No. 2, the village of Kupa (Byelorussian SSR)., at a depth of 180 m.

Immediately above that depth are sandstones containing an Orthis fauna (glauconite from depth of 175 m is 460 m. y. old); they are underlain by blue shales of the Baltic series, with an Olenellus fauna (glauconite from 257 m turned out to be 540 m. y. old).

Glauconite samples from barren sedimentary formations in the Ryazan-Pachelma trough, below the blue shales, are considerably older, probably Precambrian (Sinian). We obtained absolute age figures of 598 m. y and 606 m. y. for the upper glauconitic member, and 723 m. y to 770 m. y. for the lower (Pachelma formation of the Serdobsk series.

Period	Glauconite sampling location	Rocks	K, per-cent	$\frac{Ar^{40}}{K^{40}}$	Absolute age in million years	Presumed geologic age
Ordovician	Estonian SSR, Maardu mine, drift 5 (I. M. Kurman)	Sandstones with Orthis Megalaspis leuchtenbergii fauna	6.65	0.0297	470	Lower Ordovician
	Byelorussian SSR, village Kupa, test R-2, 175 m (Ye. P. Bruns)	Argillaceous sandstones with Orthis fauna	6.78	0.0290	460	
Lower Cambrian	Byelorussian SSR, village Kupa, test R-2, 257.8 m (Ye. P. Bruns)	Sand streaks in shales	4.66	0.0347	540	Baltic series, Lower Cambrian blue shales
Cambrian	Ryazan-Pachelna trough, village Lipyagi, test R-2, 1429 m (I. Ye. Postnikova)	Sandstones	5.84	0.0384	587	Valday series (Laminaria formation of I. Ye. Postnikova)
Precambrian	Serdobsk, test R-2, 1380 m, (I. Ye. Postnikova)	Sandstones with pollen Palaeopirosaceus atavus baum., P. poroscus Naum., Phosphosphaera laminatita Naum.	5.33	0.0394	600	
	Serdobsk, test R-2, 1758 m (M. M. Tolstikhina)	Sandstone	4.90	0.0492	726	Serdobsk formation
	Serdobsk, test R-2, 1787 m (I. Ye. Postnikova)	Sandstones with pollen remains of Brochosaccus antignus Naum., Phosphosphaera notata Naum.	6.12	0.0506	743	
[Older Precambrian?]	Settl. Zubova Polyana, 1377 m (Z. P. Ivanova)	Base of Pachelma formation	6.49	0.0527	767	
	Pugachev, test 10, 1850-1870 m, (V. D. Shutov)		4.26	0.0530	770	
	Village Kaverino, test 10, 1597-1609 m		5.80	0.0680	943	
	Pugachev, test 10, 2161 m (V. D. Shutov)		3.90	0.0640	898	
	Ural Front, Serafimovka test 119, 2898 m		6.31	0.103	1290	

Glauconite from the boundary with the underlying Kaverino formation turned out to be even older (898 and 943 million years). Finally, a glauconite sample from the Lower Bavlinka formation in the Volga-Ural trough yielded the highest age figure (1,290 million years), although most geologists correlate it with the Serodobsk series.

Absolute age was determined also for glauconite samples from ancient deposits at the north margin of the Russian Platform (hyperborean of the Murmansk-Kola re-

gion) apparently contemporaneous with the Sparagmites formation of Norway and the Sinian of China, and usually correlated with the Serdobsk formation (see table 8). Figures in Table 8 are in good accord with the above data, as well as with those of E. K. Gerling (1,000 - 1,035 million years).

TABLE 8

Glauconite sampling location	K, per cent	$\frac{Ar^{40}}{K^{40}}$	Absolute age in million years
Sredniy Peninsula, Malaya Volkovaya bay (B. M. Keller)	5.90	0.0610	865
Sredniy Peninsula, Malaya Volkovaya (B. S. Sokolov)	6.21	0.0775	1,040
Sredniy Peninsula, Malaya Volkovaya (B. S. Sokolov)	6.93	0.0790	1,059
Kil'din Island (B. M. Keller)	5.89	0.0645	904
Kil'din Island (B. S. Sokolov)	4.50	0.0750	1,018

West slope of the South Urals (Bashkirian Anticlinorium)

Sedimentary rocks of the Bashkirian anticlinorium present a classic late Cambrian section, designated as Rhiphean by N. S. Shatskiy.

The age of these ancient barren formations has been the subject of a lively discussion by different schools of stratigraphers, tectonicists, and lithologists.

A generalized standard Rhiphean section of the Urals can be presented as follows: At the base, the Archean (?) Tartash gneisses are overlain with an angular unconformity by the Bruzyansk series, with the Yurmatin series above it. Resting on the latter, with a major erosion break and basal conglomerates, are the five formations of the Karatau series (from oldest to youngest): Zilmerdak, Katava, Inzer, Minyar, and Uka. Thus the Rhiphean section is culminated in the Uka formation. Above that there lies (also with a break) the Asha formations whose age is perhaps the most controversial in the geology of the Urals. Some students believe it to be Devonian; others believe it to be Silurian or Ordovician. There is a growing body of evidence, however, that it is Cambrian, possibly Precambrian.

We analyzed seven glauconite specimens from different formations of this most interesting section. The results suggesting that the Uralian Rhiphean is close in age to the sedimentary mantle of the Russian Platform, are presented in Table 9.

The oldest is glauconite from the Avzyansk formations (upper part of Yurmatin series), with its age (1,263 million years) very close to that of the Lower Bavlinka formation.

Likewise, the age of the Karatau series (616-932 m.y.) is comparable to that of the Serdobsk series from the Russian Platform (606-943 m.y.), which fully corroborates their established correlation.

The age of the overlying Asha formation (573 m.y.) turned out to be very close to that of the upper Karatau formation (616 m.y.) That lead us to believe that the age discrepancy between the Uka and Asha formations is not too great and that the Asha formation may be Lower Cambrian.

Siberia

Out of all the samples on hand, only six were analyzed from ancient formations in the Aldan shield, Yenisey range, and the western fringe of the Aldan shield. The results are presented in Table 10.

TABLE 9

Glauconite sampling location	Rock	K, percent	$\frac{Ar^{40}}{K^{40}}$	Absolute age in million years	Formation
Kiselev Spring on road between mountains Asha and Min'yar, Asha R. (I. Ye. Postnikova)	Sandstone	5.79	0.0372	573	Lower part of Asha
Zilim River basin, Kamyshta area (Yu. R. Bekker)	Dense sandstone	5.00	0.0407	618	Uka
Bassa R. basin, area of village Kulamas (Yu. R. Bekker)		6.14	0.0405	616	
Mt. Min'yar area (Yu. R. Bekker)		3.55	0.0520	760	Lower part of Min'yar (Minksk sequence)
Urta-Ayry R., Nugush R. basin (N. P. Verbitskaya)		4.45	0.0620	876	Inzer
Min'yar Lake, pit 19 (I. Ye. Postnikova)	Quartzitic sandstone	5.90	0.067	932	Lower part of Inzer
Bol'shoy Katav R., 10, 5 km above village Zaprudovka		5.85	0.1000	1,263	Avzyansk (upper part of Yurmatin series)

TABLE 10

Glauconite sampling location	K, percent	$\frac{Ar^{40}}{K^{40}}$	Absolute age in million years	Geologic age
Lena River, at the mouth of Patoma R. (G. A. Kazakov)	6.23	0.0320	502	Lower Cambrian (Zherbinsk formation, Aldanian stage)
Ushakovka R.	3.41	0.0400	609	Motsk formation, Aldanian stage
Teya R, Yenisey range (M. A. Semikhatov)	5.28	0.0510	747	Chividensk formation
Nizhnyaya Tunguska R. (V. I. Dragunov)	2.42	0.0665	925	Test hole (Sinian)
Yenisey Range (M. A. Semikhatov)	4.09	0.0870	1,140	P'o-kuo formation (Sinian)
Olenek uplift, Ulakhan-Yuetteekh R. (I. V. Pokrovskaya)	2.77	0.1000	1,263	So-lo-li formation (Sinian)

Chinese Platform

It was extremely interesting to correlate the age data for glauconite samples from ancient deposits of the Russian Platform, Murman-Kola region, Urals, and Siberia, with those from classic sections in the Chinese Platform. Material was kindly put at our disposal by Professors Chey Yü-ch'ih and Yeh Lien-chiung.

Four samples were analyzed. The results are listed in Table 11.

TABLE 11

Sample	Glauconite sampling location	K, percent	$\frac{Ar^{40}}{K^{40}}$	Absolute age in million years	Geologic age
462	Hsin-shan, district Wu-t'ai south of village Chu-kuan-ssǔ, Shansi province	6.41	0.0330	516	Lower Cambrian, Man-t'ou formation
186-A	District Tsai, Tsin-ehr-yu village, Hopeh province, member A	5.52	0.0617	873	Tenth division of Sinian, Chin-erh-ya-yu
186-C	District Tsai Tsin-ehr-yu village, Hopeh province, member B	5.70	0.0633	890	
K-1	He-ya-jang-tz'ǔ, district Ping-wu-zyun, Hopeh, member B	2.48	0.0774	1,040	Fourth division of Sinian, manganese horizon

Table 11 shows that the age of the Man-t'ou formation as obtained on glauconite is close to that of the Zherbinsk formation, Aldanian stage, which overlies the thick Yudomsk formation, barren of fauna but presumably Aldanian. The findings of a Redlichella fauna – not typical of the base of the Cambrian – in the Man-t'ou deposits suggests that the Sinian-Lower Cambrian boundary may lie somewhat below the 500 m. y. line. Of interest in this respect are the very high age figures (870 m. y. to 890 m. y.) for glauconites from the uppermost Sinian horizons. On the basis of these data, a considerable break can be postulated between Sinian and Cambrian deposits. It is quite evident that work of the absolute-age determination for glauconite from Sinian deposits should be carried on, because any conclusion would be premature on the basis of the data extant.

CONCLUSIONS

This is an attempt at bringing together the absolute and relative geochronologies by determining the absolute age for glauconite syngenetic with the enclosing rocks. It can be considered successful. The authors believe that the data obtained for the Mesozoic-Cenozoic and lower Paleozoic-upper Proterozoic are fairly reliable and bear testimony to great possibilities for the Argon method. Obtained for the first time were age figures in the interval 500 to 1,300 m.y. before the present, for most ancient sedimentary formations in the Russian Platform, Urals, and East Siberia. Thus the "blank spot" in absolute geochronology (from Jotnian to Cambrian) gradually shrinks. Obtaining new data on the most ancient barren formations whose differentiation and correlation are extremely difficult should be given priority by workers in this field. In this paper, the upper and lower Paleozoic have not received adequate treatment because of the lack of reliable dating material. In view of the divergence between our data on the Lower Permian-Silurian interval and the present absolute age scale we deem it necessary to obtain appropriate data for a number of regions.

It appears that using glauconite in determining the absolute age will be of real help in drawing more accurate stratigraphic boundaries and in correlating barren sedimentary formations.

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CLASSIFICATION OF TECTONIC FORMS[1]

by

I. I. Potapov[2]

REVIEWER'S NOTE

Well worth publishing to give Americans a good idea of the Russians' meaning of tectonic terms. I am not sure I would agree with the order of importance or rank of the structures but then neither would other Russians.

ABSTRACT

The author presents a tectonic-form classification which may be useful in ultimately solving the problem of tectonic subdivision of the Don and lower Volga basins. --Author's English summ.

* * * *

On examining the "Tectonic Map of the U.S.S.R. and Bordering Countries, Scale 1:5,000,000" [6] one is struck by the fact that the data and nomenclature of the tectonic forms shown there are not entirely in order. It is incomprehensible, for example, why shields and platforms, and anteclises and syneclises[3], appear as subunits of identical order (first order); or why, in the area of the Mesozoic-Cenozoic mantle, a "Greater Caucasus Depression" is distinguished (that is, an actual tectonic form of the lower Paleozoic): the differences between syneclise, basin, and depression are not clear. An even more bewildering question arises when we compare the tectonic terminology of the map in question with that adopted in other works.

Difficulties in the choice of designations for tectonic elements often arise in establishing tectonic zoning intended for a more rational prosecution of mineral surveys (particularly gas and oil), and also in the delineation of tectonic forms of varying rank.

[1] Translated from: Skhema klassifikatsii tektonicheskikh form, Sovetskaya Geologiya, no. 8, 1960, pp. 66-74. Footnote to title in original reads "Printed in the order of discussion."

[2] Rostov State University.

[3] The reviewer of this paper for IGR has suggested that "anteclises" and "syneclises" are better translated "anticlinoria" and "syneclinoria." However, others have advised that these terms should not be interchanged because they imply differing concepts of structural development. The following definitions are from the AGI Glossary of Geology and Related Sciences, 2nd edition: anteclise -- broad uparched structure of the basement generally with thin sedimentary cover; synclise -- deep structural depression of the basement that developed over a long period of time and is filled with thick cratonic sediments.--M.R.

In connection with the problem of a tectonic zoning for the Don and lower Volga basins, we have attempted to work out a classification for tectonic forms. It is on the basis of data adduced in the published works of V. V. Beloussov, N. S. Shatskiy, V. Ye. Khain, M. F. Mirchink, M. V. Muratov, and other investigators [1, 2, 3, 4, 5, 6], as well as materials collected by local geologists, that our classification scheme has been constructed. It may be of value in resolving the problem of a unified tectonic classification.

Each of the tectonic forms of various order examined below, in point of structure and geological history, appears as a more or less homogeneous block of the upper zone of the earth's crust. In delineating such blocks for the purpose of tectonic zoning, it is first of all necessary to consider the peculiarities of the formations which compose the upper structural stage. Thickness, in particular, is of great significance for tectonic zoning. For example, in the Volga-Don area, the scant thickness of the formations comprising the Quaternary stage precluded taking its features into account; and, for the same reason, the morphology of the Mesozoic-Cenozoic deposits was utilized for the tectonic zoning of the area coinciding in the plan with the Donets folded district (Hercynian).

In our classification, only those tectonic forms which have arisen in sedimentary and metamorphic rocks have been considered.

PLANETARY (SUPERORDINAL) TECTONIC FORMS

Tectonic forms of Planetary scale

Tectonic forms of planetary scale are distinguished by two major (superordinal) elements, different in structural principle.

Some of these appear as tectonically mobile, lineally extended belts of the earth's crust,

within whose borders geosynclinal systems arise and develop. The latter are converted into folded mountainous structures at the termination of the geotectonic stages of development of the belts; then they are consolidated, lose their mobility, are eroded, and pass on toward platform development. Thus it is that mobile belts contain the very largest geosynclinal and folded tectonic forms.

At the present time some mobile belts are represented almost entirely by folded systems (the Alpine-Himalayan Belt); while others (the Eastern-Pacific Belt and the Western-Pacific Belt) include in approximately equal numbers both contemporary geosynclines, often found in the zenith of their development (the deeps of the Pacific found near archipelagos with active volcanoes), and folded mountainous systems (the ranges of Eastern Asia, the Cordilleras, the Andes). Geosynclinal and folded systems are commensurable in extent with mobile belts, and, like the latter, are related to superordinal tectonic forms.

Another aspect of planetary tectonic forms is platform regions (continental and oceanic): enormous areas, monometric in their outlines and significantly less mobile than belts. Continental platform regions (the Eurasian, African, North American and others) are composed of strongly metamorphosed rocks of an eroded folded foundation which at points appears at the surface, and of a quite thick platform mantle which consists of almost horizontal sedimentary layers deposited on the basement. The analogous areas within oceans (Pacific, Atlantic, and others) are structurally less distinct; the thickness of their mantle is obviously insignificant, and, in places, nonexistent.

Platform Regions

Platform regions, in line with the heterogeneity of their structure, can be broken down into shields [shchity], platforms proper [platformy], and platforms [plity], which are commensurable in area. These are also superodinal tectonic forms of the earth's crust, ranking in size and importance with folded and geosynclinal systems.

Shields

Shields (the Baltic, Ukrainian and others), the projections of the crystalline basements of platforms on the surface, are composed of Archean and Proterozoic dislocated metamorphic and magmatic rocks. Since the Paleozoic and up to the present time, shields have been stable, uplifted elevations and areas of erosion.

Platforms

Platforms proper (the Russian, Siberian, North American, etc.) are enormous, little-mobile, isometric sections of the earth's crust which envelop shields or are adjacent to them. As distinguished from shields, platforms proper are characterized by typical two-phase structure. They posses a crystalline basement [fundament] (eroded Archean and Proterozoic folded and magmatic formations) and a nonconformable mantle which covers the basement, consisting of rather thick series of horizontal strata of the Paleozoic and younger age.

Platforms are slightly uplifted sections of the earth's crust, of two-phase structure analogous to that of platforms proper, which they adjoin. They also posses a basement and platform-type mantle. Eroded folded and magmatic formations, mainly Paleozoic, figure in the structure of the foundations of platforms and their mantle is formed of weakly dislocated Mesozoic-Cenozoic rocks. Platforms thus take the shape of young, that is, post-Paleozoic platform areas, as distinct from platforms proper, which are post-Proterozoic. The West-Siberian and Turanian Platforms have such a structure as shown on the "Tectonic Map of the USSR and Adjacent Countries" [6]. Since they are essentially the peripheral, or younger, portions of platforms proper, their designations should derive from those of the latter, or be assigned according to a geographical principle. In this respect the term "West Siberian Platform" is appropriate, but "Turanian" should be replaced with "Aral Region" or "Kara Kum." The more westerly area, analogous in structure and designated as the Scythian Platform by Muratov [3], should be called either the South Russian Platform, or, after Mirchink [2], the Fore-Caucasus Platform. The former designation signifies that the platform in question does not stand in contrast to the Russian Platform, but is an internal, younger portion of it.

Our classification outline for tectonic forms follows. All the finer tectonic forms are given here in descending order. Superordinal forms are stated in chronological order from left to right; in other words, in the order of their succession in the geotectonic process. To simplify the outline it was necessary to transpose the "Shields" and "Platforms" columns.

FIRST-ORDER TECTONIC FORMS

The breakdown of planetary tectonic forms into smaller units was effected with consideration of their principal differences in development and structure, and, so far as possible, only tectonic terminology was employed. In the classification proposed here, almost no use has been made of such terms as depressiya (depression or basin), vosvysheniye (elevation or prominence), ponizheniye (subsidence or depression), kotlovina (basin), vpadina (basin, trough or depression), and podnyatiye (uplift): terms which frequently have a geomorphological connotation. In a number of instances these customary terms

Classification for Tectonic Forms

Planetary (superordinal) forms	Mobile (geosynclinal) belts		Platform-type regions (continental, oceanic)		
	Geosynclinal systems	Folded systems	Platform	Platform proper	Shields
First-order forms	Geosynclinal regions and their external, internal and local portions	Folded regions, meganticlinoria, megasynclinora	Synclises, anteclises, massifs, projections, dislocations		
		Foredeeps and depressions			
		Submontane depressions	Marginal syneclise		
Second-degree form	Geosynclines, Geanticlines (internal, external and marginal types)	Anticlinoria, synclinoria, intermontane troughs, median masses, buried forms	Intraplatformal depressions and basins. Tectonic elevations, flexures, saddles, terraces, monoclines, swells, vaults		
Third-order form	Internal depressions. Internal uplifts	Synclines, anticlines, brachysynclines, buried folds, diapir folds, troughs	Structures, domes, noses and terraces, interstructural depressions and basins, troughs		

have been retained, but with the addition of clarifying words to fix their tectonic significance: for example, tektonicheskiye podnyatiya (tectonic uplifts); vnutriplatformennyye vpadiny (intraplatformal basin); mezhstrukturnyye vpadiny (interstructural basins); etc.

Terms

The generally accepted tectonic terms: fold, anticline and syncline and their derivatives, folded zone, anticlinorium, synclinorium, etc., must be used only in designating tectonic forms found within folded systems and in those portions of platform regions from whose contemporary structure a platform-type mantle is absent. The terms anteclise and syneclise (analogous to anticlinorium and synclinorium), reflecting as they do the complex structure of large convex and collapsed portions of platforms proper and of platforms, are quite appropriate. As the synonyms of terms like anticline and syncline, which designate in folded regions lineally extended and steeply-structured forms of third order, we may use in the case of platform-proper and platform regions such terms as structure (positive form) and interstructural depressions and basins (negative), to which are peculiar either a protracted form or an isometric and gentle depositing of layers.

Geosynclinal systems (superordinal tectonic forms) form geosynclinal regions together with their internal, external and marginal portions, exhibiting their special geotectonic regime and facies, named for geographical signs (forms of first order).

The internal and external portions of a geosynclinal region during the process of development experience transformation into a mountain-folded region at the end of the geotectonic cycle (the Urals, the Caucasus, the Tien-Shan, etc.). Marginal portions of a geosynclinal region are transformed, in lesser degree, and present the beginning of the internal zones of foredeeps. Geosynclinal regions, being zones of sedimentation, are covered with the sea during the course of almost their whole existence.

Meganticlinoria and megasynclinoria, and the folded zone and submontane troughs corresponding to uplifts appear as first-order froms to which folded systems are subordinate.

Folded Region

The folded region presents itself as a complex of linear troughs belonging to all three orders, which have arisen at the end of the geotectonic stage in an area of predominantly geosynclinal character. In most cases folded regions correspond to folded mountainous countries and are named for them.

Meganticlinoria

Meganticlinoria are lineally extended mountainous structures of complex structure within a folded region, of general convex form, complicated by structures of second order, to judge by the morphology of the uppermost and youngest layers. In the central folds of the meganticlinorium are found more ancient sedimentary rocks; and in the peripheral ones, younger sedimentary rocks. The folded Caucasus and Urals mountainous structures are examples of such tectonic forms.

Megasynclinoria are analogous to meganticlinoria, but are concave forms of the first order. The folded zones of the Caucasus and Urals, or of the Donets Basin, may also serve as examples, if we judge by the morphology of

the middle and lower layers collected in the folds.

Submontane troughs - See under foredeeps.

Tectonic forms developed in platform-type areas possess specific structure and a more peaceful tectonic regime. They appear for the most part in the lower and middle horizons of the sedimentary cover. Therefore, almost all of such forms fall into the category of buried elements of a tectonic structure.

Syneclises and Anteclises

Syneclises and anteclises appear as the typical platform-type structures possessing biphasal structure.

Syneclises are monometric or elongated, quite large in area, collapsed portions of platforms proper and platforms, covered with a thick series of platform-type mantle. Examples include the Moscow syneclise, the North-Caspian, the Ukrainian, the Pecherian, etc.

Marginal syneclises - See under foredeeps.

Anteclises are tectonic forms, usually of smaller area than the syneclises, and commonly extended along the strike of an ancient fold of a platform or platform proper. They possess relatively thin platform-type mantles and are complicated by second-order tectonic forms. Such structures are the Belorussian, Voronezh, Volga-Urals, etc., anteclises.

Massifs are comparatively small extensions onto the surface of the pre-Paleozoic crystalline foundation on the vaults of anteclises, which arose as the result of erosion of the Paleozoic mantle (Anabar massif). It is convenient to designate as massifs both the uplifted basement of an anteclise and the earlier eroded uplifts of the pre-Paleozoic basement, now found under the Mesozoic-Cenozoic mantle of the young platforms.

Analogous portions of the Paleozoic folded basement within the borders of platforms, exposed as the result of mantle erosion, are called projections. Platforms and platforms proper may be recognized which are complicated by equally positive and negative forms of second order.

At the end of the tectonic stage, in places where geosynclinal regions adjoin those of platform type, before a rising folded mountain terrain, there usually appear foredeeps [krayevyye progiby, literally, "marginal depression"]: negative tectonic forms of first order in the form of trenches (such as the foredeeps of the Urals, Carpathians, and Caucasus [Preduralskiy, Predkarpatskiy, Predkavkazckiy]). The term peredovoy progib ("forward depression") is commonly applied to these forms. Foredeeps do not appear within shields or in areas of juncture between shields and platforms.

Cross-sections of foredeeps are usually markedly asymmetrical. Submontane or internal portions of foredeeps are comparatively deeply depressed zones with characteristics of geosynclinal development. They are filled with thick (5 km and more) terrigenous sedimentary formations, and are marked by linear, quite steep, folding. These areas, formed on the site of former marginal portions of geosynclinal regions, and at the present time marked by anticlinoria, synclinoria and separate folds, are designated by the term submontane depressions [predgornyye progiby]. As major peripheral negative folds they unquestionably fall into the category of folded regions.

The external portions of foredeeps, significantly broader and gentler, and slightly collapsed, have clearly marked platform-type traits. They possess biphasal structure and are covered with a comparatively thin (up to 2.5 kilometers, rarely more) series of nonmetamorphic sedimentary rocks, and are marked by gentle, dome-type and salt-bearing structures comprising a group of second-order tectonic forms of negative or positive direction. These portions should be designated external zones of foredeeps.

Foredeeps are commonly divided by transverse uplifts into separate monometric marginal basins [krayevyye vpadiny], named for geographical signs. The internal portions of these marginal basins may be termed marginal syneclises in order to emphasize their relationship to platforms.

The borders between submontane depressions and marginal syneclises are the borders between folded zones, and platforms and platforms proper.

SECOND- AND THIRD-ORDER TECTONIC FORMS

The tectonic elements enumerated above are complicated by second- and third-order forms.

Geosynclinal regions exhibit internal, external and marginal geosynclines and geanticlines (second-order forms), as well as internal depressions and uplifts (third-order forms) of widely known nature. We should merely emphasize that contemporary forms of a given type are occupied by water basins, where thick layers of various sedimentary rock are deposited. During their development second- and first-order geosynclinal forms undergo transformation (are changed from negative to positive forms) but the morphology of third-order forms does not change.

Anticlinoria and Synclinoria

Within folded regions, among second-order forms the most common are anticlinoria and synclinoria: in other words, lineally extended convex or concave folded structures of complex structure. Such forms appear within the borders of the Caucasus, Urals, Donets and other meganticlinoria.

Intermontane troughs, filled with coarse-fragmental continental rocks, have appeared in the intermontane zones of meganticlines, and apparently belong to the category of second-order tectonic forms.

Median masses belong in the same category; these are rigid uplifted blocks of an ancient foundation with thin (and sometimes no) mantles of weakly dislocated rocks, contemporaneous with the surrounding geosynclinal formations of a folded region.

The noted second-order tectonic forms, related to local interruptions in the sedimentation process, have been conditioned by separate phases of folding, and commonly fail to exhibit younger sedimentary strata: that is, such forms may simply be buried. Finally, third-order forms in folded regions include separate anteclise- and synclise-type folds, brachyanticlines and brachysynclines, troughs, buried folds, diapir folds, and so on.

For the designation of tectonic forms developed in folded regions we should avoid such terms as structure [struktura], basin [vpadina], and uplift [podnyatiye]: terms generally used for the designation of platform-type dislocations.

In platform-type regions second-order forms are represented by swells, arches, intraplatform depressions and basins, tectonic uplifts, saddles and flexures, terraces and monoclines.

Swells are extended, gently raised portions of platforms and platforms proper, marked by third-order structures (the Vyatka, Kama, Don-Archedin swells, etc.).

Arches may be called more or less monometric second-order, forms, marked by a number of gentle dome-like structures.

Intraplatformal depressions are extended, buried portions of platforms and platforms proper, often oriented parallel to the ancient folding of the basement, and covered with sedimentary rock of greater thickness (Manych and Pachelm Depressions, etc.).

Intraplatformal basins can be described as approximately isometric portions of platforms and platforms proper, characterized by a general condition of being buried and by a certain increase in thickness of the sedimentary cover and the presence of tectonic structures of third order.

Tectonic uplifts may be described as inadequately defined, fairly extensive positive tectonic forms of second order.

Terraces are flat, extended areas, often of step-like character, developed in the juncture zone between negative and positive tectonic forms of first and second order (the Volga terrace).

Monoclines are large, often flat, areas on the slopes of anteclises and the sides of syneclises, and are marked by third-order structures.

Saddles can be described as transversely uplifted areas within extraplatformal depressions (the Latvian Saddle, the Kustanay Saddle, etc.).

Flexures are tectonic forms which often delineate shields from platforms, and first- and second-order positive tectonic forms from negative ones. Within these flexures of the basement, block-type transitions arise or varied third-order structures often containing intrusive nuclei of rock salt are seen in various states of erosion on the platform mantle. The so-called Stalingrad flexure, developed along the northwestern flank of the North Caspian syneclise, and evidently also the analogous zones of the Ukraine, along which salt-bearing structures are distributed, may both be taken as examples of this type of second-order tectonic form.

The above-mentioned tectonic elements of platforms and platforms proper are not, as a rule, marked by third-order forms: "structures" (positive form), domes, structural extensions, structural terraces and interstructural depressions and basins (troughs).

The structure may be taken to be any elongated tectonic third-order uplift found within platforms and platforms proper.

Domes are isometric third-order structures.

The structural extension, or nose, is an extended flattening out of downward-dipping layers along the dip of a monocline. The structural terrace exhibits similar flattening, but is along the strike. Such extensions and terraces often include the usual tectonic forms within deeper zones.

Finally, buried areas of layers between separate structures may be designated as interstructural depressions if of elongated form, and interstructural basins or troughs if more or less isometric.

In designating third-order forms within

platforms and platforms proper, it is of course not permissible to employ the terms anticline and syncline, anticlinal zones, synclinal zones, folded zones, lines, and other such items.

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NEOTECTONICS OF EAST AND CENTRAL CIS-CAUCASUS[1]

by

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REVIEWER'S NOTE

The article centers on late Cenozoic deformation in this interesting structural setting, and isopachous and structural elevations are shown by Figure. 1.

ABSTRACT

Problems of neotectonics of east and central Ciscaucasia a part of the extensive Mid-Caspian oil and gas basin and characterized by a complicated and heterogeneous structure, are considered.

An accompanying map sums up the recent movements during the Middle Miocene and the Quaternary.

Great regions, chiefly of recent downwarpings with sediment accumulation of considerable thickness (the Terek-Caspian marginal depression, the Near-Caspian syneclise, and the Manych depression) are delineated as well as regions of recent uplift (Stavropol and Yergeni), where middle Miocene to Quaternary deposits are either absent or relatively thin. These extensive regions are complicated by a number of local uplifts grouped into definite zones with a somewhat east-west strike in the southern part of the territory. The linearity of local uplift zones is not so well defined in the northern part of the region. Considerable magnitude of neotectonic movements during the latest stage is reflected in a number of local uplifts in the Stavropol region, outlined by isobases 600-500 m, as well as by certain uplifts within the southern Yergeni.

In areas of latest downwarping most of the local uplifts are only relatively expressed. Areas where the most recent movement is predominantly uplift, is in contrast to a background of considerable but nonuniform subsidence. To these areas the Near-Caspian neotectonic unit and a number of local uplifts of the Peschanoye-Promyslovsk Near-Caspian zone outlined by isobases from +100 to +500 m are referred. Significant recent uplifts are observed in the vicinity of the Peschanoye village, comparable in magnitude to uplifts in the southern Yergeni and Stavropol region.

In many cases the general distribution of structural features and local uplifts is inherited from older structural-tectonic units. Accordingly the study of the latest earth crust movements acquires great significance, especially in oil and gas prospecting. --Auth. English summ.

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The tectonics of Ciscaucasia and the adjacent territory of the western Near-Caspian [Prikaspiskaya Nizmennost'?] and Yergeni have been studied by A. P. Karpinsky [22], A. D. Arkhangelsky [1], N. S. Shatsky [46, 47], M. V. Muratov [27, 28], I. O. Brod [5], and others.

Considerable data on the northern Ciscaucasus and adjacent regions have been gathered in the last few decades: many papers have dealt with various questions on tectonics, the delineation of structural zones, description of local uplifts and their distribution [4-10, 12-14, 17, 18, 23, 26, 27, 29, 31, 33, 35-37, 39, 41, 42, 46, 47, 51, 52.] Data from these have been incorporated in summaries by M. V. Muratov [28, 29], I. O. Brod [5], and M. P. Kazakov [24, 25].

The tectonics of the northern Ciscaucasus and adjacent regions are complicated. Here occurs the juncture of the southeastern part of the Russian platform, which has a Precambrian basement, with the Epihercynian Scythian platform, described by M. V. Muratov. The location and character of the line of juncture of these two tectonic zones of different ages are still not sufficiently clear.

In his works on the tectonics of the Donets basin, N. S. Shatsky deals with the position of the southern border of the Russian platform. On the basis of facies and thickness studies, he concluded in 1937 that the Donets basin is a foredeep of the Hercynian folded zone, which zone is now covered by Mesozoic-Cenozoic rocks [46]. Later, N. S. Shatsky wrote that the Russian platform is bounded on the southeast by an upper Paleozoic foredeep, which is the continuation of the Donets basin warping on one side, and is bounded on the other side by the

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[1] Translated from Neotektonika vostochnogo i tsentralnogo predkavkazya; Sovetskaya Geologiya, 1960, no. 8, pp. 75-86.

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Urals foredeep [47]. However, the position and character of the Hercynian foredeep is still interpreted differently. For instance, in the scheme of tectonic zoning of the Bol'shoi Donbas and its adjacent territories by A. Ya. Dubinsky, this downwarping is considered to extend approximately to the latitude of northern Stavropol with its axis through the towns of Rostov and Ipatovo. I. O. Brod [5] located the Hercynian foredeep north of the main Donets basin thrust and extending toward Stalingrad. The downwarp is filled with Mesozoic deposits with underlying thick Permian saline strata and the Kotelinikovo-Astrakhan uplift is considered as its southern boundary. A somewhat different picture of the Hercynian foredeep position is shown in the 1:5,000,000-scale Tectonic Map of the U. S. S. R., N. S. Shatsky editor, and described by M. V. Muratov [27]. M. P. Kazakov [23] and others have more or less the same viewpoint which is that Hercynian folding stretches from the Donets basin through Kotelnikovo to Astrakhan. V. A. Kopeliovich [25] published convincing data from an Astrakhan drillhole which revealed a complex of Artinskian sediments analogous in composition and structure to molasse deposits of the Aktyubinsk Near-Urals. An accumulation of these sediments, containing pebbles with Carboniferous fauna indicates that south of Astrakhan Hercynian mountain structure is to be found. In the Kotelnikovo region Carboniferous rocks of the Donets type are found beneath Mesozoic sediments. Within the above-mentioned foredeep on the Mesozoic deposits, a number of complicating local uplifts stand out. These are the Astrakhan, the Ovatin, Zavetnin and Kotelnikovo uplifts which occur in a linear zone.

Further south of the Hercynian foredeep, within the folded basement of the Epihercynian platform, are large uplifts and folds. Their structural outline is inherited and was formed in several cases in later periods of the Mesozoic and Cenozoic. Cretaceous, Paleogene, Neogene and Quaternary deposits comprise the platform cover; older rocks can be found in separate parts of the described region also. These rocks have been deformed into a number of basin and range structures, some coinciding roughly with anticlinal and synclinal zones of the Paleozoic folded basement others apparently formed in a more recent period in response to intensive tectonic movements of the Caucasus geosynclinal region.

In the Ciscaucasus are two large isolated basins: the Terek-Caspian in the east and the Indolo-Kubansk in the west. These are deep downwarps which originated on the southern border of the Epihercynian platform along the rising Caucasus mountain structure. An asymmetry of pattern is characteristic: the southern limbs are steep and complicated by the frontal folds of the Caucasus, the northern limbs are gentler. These foredeeps are separated by the transverse Stavropol uplift, a massif of irregular form with a Paleozoic basement at relatively shallow depth (1,000 to 2,000 m). Several local uplifts have been located by geophysical methods and test drilling within the massif's platform cover; they are aligned NNW-SSE parallel to the structural trend of the Caucasus.

To the north the Terek-Caspian foredeep changes gradually to the flat Nogaysk depression of platform type, complicated by local uplifts and merging further with the Near-Caspian syneclise of the Russian platform where salt domes are of special importance. These depressions are reflected in the surface topography as extensive lowlands. To the west they are bordered by the eastern flanks of the Stavropol and Yergeni highlands.

The Yergeni arch is an asymmetric structure extending from the lower course of the Don along the Salo-Manych range. It is characterized by a relatively high occurrence of the Paleozoic basement. Geophysical research and drilling in recent years indicate this arch continues east-southeast from Yergeni into the Near Caspian Lowland [Prikaspiyskaya Nizmennost'] in the direction of the Caspian Sea, which it goes beneath south of Astrakhan. This linear zone (the Don-Caspian arch of Yu. A. Sudarik) is 50 or 60 km wide and is complicated by a series of local uplifts in the form of domes or brachyanticlines, described in papers by F. F. Panteleev [36], Yu. A. Sudarikov [39], G. N. Rodzyanko [38], Ya. S. Eventov [50] and others. To this series belong the well known uplifts of: Manych, Beloglinsk, Remontnensk, Stepnovsk and others in the southern Yergeni; namely Yartinsk, (Peschanoye village), Zubuk, Oleynikovo and Promyslovo all within the Prikaspiyskaya Nizmennost'.

The Yergeni uplift is separated from the Stavropol uplift by the Manych depression. According to M. V. Uskov [41] the top of the Carboniferous in the deepest part of the warping is located about 3,000 m deep, and the thickest sediments in the depression are Cretaceous and lower Tertiary.

The Don-Caspian arch within the Yergeni is bordered on the north by the Zimovnikovsk-Yashkulsk trough on whose extension, in the near-delta part of the Volga, the Astrakhan trough becomes apparent (the Bakhtemirsk, according to M. P. Kazakov). The Zimovnikovsk-Yashkulsk and Astrakhansk troughs separate the Don-Caspian arch from the Kotelnikovo-Astrakhan uplifts, which complicate the Hercynian frontal folds.

Very roughly, this is the structural plan of the described territory, which also defines to a certain extent its latest structural development. The problem of these latest tectonics is very complicated and were poorly understood, before World War II, B. L. Lichkov [29] and

G. F. Mirchinko [34] made the first summaries to deal with this question. The most recent movements of the earth's crust and their development within the limits of the Russian platform were examined from different viewpoints. Papers by G. F. Mirchinko are of special importance; he concluded that the most recent movements can be understood only as related to previous tectonic history. He also outlines the basic direction for the solution of this problem. Starting approximately with 1946, the question of studying the latest tectonic movements of the earth's crust and the relation of buried structure with surface relief on the other becomes more and more important.

Broad complex geological research was launched in a number of wide regions of the country in connection with the search for oil and gas. Much information on geologic structure, tectonics and geomorphology of a number of zones on the Russian platform was gathered and a series of articles on problems of the most recent tectonics of separate territories was published. The monograph by N. I. Nikolaev [33] belongs to this period; it played an important role in appraising recent movements on the Russian platform, and in the development of study methods. In more recent years, a great number of articles has been published, dealing with questions of geomorphology and the most recent movements in different parts of the Russian platform. In all these papers, the relation of most recent movement to buried strucutre as well as surface relief is stressed. This relation between ancient structures, recent uplifting and relief is of great theoretical and practical meaning, especially in prospecting for oil and gas in regional or local uplifts. The study of the most recent movements and of the relief helps us to learn about the buried structure in older deposits of useful minerals. Attempts to analyse recent movements and determine their surface expression in separate sections of the described region of Ciscaucasia and adjacent regions have been made in a number of studies [14, 17, 18, 26, 31, 35, 42, 51, 52, and others]. Yet there are no summarizing papers on this problem and it is poorly understood. Recent work of the Aeromethods Laboratory of the U. S. S. R. Academy of Sciences is of great interest. This work was performed under the supervision of S. S. Shults in the north Caspian region and adjacent coasts from the west (the region of Promyslovka) and from the east. Of particular note is the complexity of the methods applied: detailed aerogeological research; study of the geologic section for obtaining data on the hisotry of tectonic development of the region in time; careful geomorphologic study of the territory to define the degree of reflection in the relief of recent elevations; geobotanical observations, etc.

The author, with N.A. Suagaev, A.A. Chistyakov, and G.N. Rodzyanko, compiled a summy map (fig. 1) of the most recent movements of the earth's crust in central and east Ciscaucasia and adjacent parts of Yergeni and the Prikaspiyskaya Nizmennost'. We considered the time from middle Miocene to Recent, when, in large areas of the Ciscaucasia, tectonic activity was intensified. The map legend is based on recommendations of the Tectonic Commission of the Geological-Geographical Section of the U. S. S. R. Academy of Sciences. The principles of this legend are described by S. S. Shults [48] and N. I. Nikolaev [34]. On the map large regions are delineated that differ in common direction and intensity of the most recent tectonic movements (continental platforms, orogenic zones, geosynclinal regions). Within the limits of these large areas recent uplifts and depressions stand out. The intensity degree of regional movements for the latest stage is defined by isolines (isobases). For platform areas a 100-m interval between isobases was used for mountain regions and a 1000-m interval for geosynclinal regions. The top of the surface of Maikop series was used as a zero isobasis in appraising recent movements of the earth's crust. We assume that the absolute mark of its height is equal to zero. The map of recent movements was been compiled from published works of individuals and the borehole data of oil organizations and local geological departments of the Ministry of Geology and Conservation of Mineral Resources of the U. S. S. R. On this map, areas of primary downwarping during the whole stage of most recent development with thick accumulation of sediments are distinguished from regions of predominant uplift where Miocene to Quaternary deposits are lacking or relatively thin. To the areas of primary intensive recent subsidence belong the Ciscaucasian structures, the Terek-Caspian trough in the east and Azov-Kuban trough in the west, separated by the transverse Stavropol uplift.

Sediments overlying the Maikop series reach a maximum thickness within the Terek – Caspian trough in the Terek region. The greatest subsidence for the latest stage denoted by the isobase (4500 m) is along the axis of the trough, situated slightly northwards of Makhach kala. This is confirmed by a well 3000 m deep near the village of Karaman which was still within Sarmatian deposits at the bottom. The axial part of the downwarp is complicated by separate local uplifts among which the most investigated are the Chervlynovsk (near the settlement of Chervlenaya) and the Mozoloks where the top of the Maikop is from 500 to 1000 m higher than in surrounding sections.

North of the axis of warping within the limits of its platform flanks, the upper Maikop deposits gradually thin to approximately 1000 m at the latitude of Bazhigan. Thus, in the area of the Terek-Caspian foredeep, during the entire most-recent stage of development, intensive subsidence has been observed which absorbed

FIGURE 1. Structural and isopachous map showing neotectonic movement of Northern Ciscaucas.

Inland Platforms

A. Platform mantle; extent of uplift expressed in positive meters:
1 - >600 m; 2 - from 500 m to 600 m; 3 - from 400 m to 500 m; 4 - from 300 m to 400 m; 5 - from 200 m to 300 m; 6 - from 100 m to 200 m; 7 - from 0 to 100 m.

B. Regions of thick Neogene-Quaternary deposits; regions of subsidence and their magnitude:
8 - from 0 to 100 m; 9 - from 100 m to 200 m; 10 - from 200 m to 300 m; 11 - from 300 m to 400 m; 12 - from 400 m to 500 m; 13 - >500 m.

C. Regions of orogenesis (alpine folding): Regions of Neogene-Quaternary deposits (foredeep) extent of subsidence expressed in negative meters.

14 - from -1,000 m to -2,000 m; 15 - from -2,000 m to -3,000 m; 16 - from -3,000 m to -4,000 m; 17 - >-4,000 m; 18 - zero isobase.

Local Uplifts

1 - Near-Sarpinsk; 2 - Nicolsk; 3 - Kotel'nikovsk; 4 - Zavetninsk (Kisilevsk) 5 - Ovatinsk 6 - Zamyanovsk; 7 - Remontnensk; 8 - Alistinsk; 9 - Kamenno-Balkovsk; 10 - Manych 11 - Beloginsk; 12 - Boya-Burulsk; 13 - Iki-Burulsk; 14 - Yartinsk (Peschanoe); 15 - Tsebuksk; 16 - Oleinikovsk; 17 - Promyslovsk; 18 - Divnensk; 19 - Apanasevsk; 20 - Dzhukhtinsk; 21 - Arzgirsk; 22 - Bezopasnensk and Kugultinsk; 23 - Ipatovsk; 24 - Letnyaya Stavka; 25 - Mirnensk; 26 - Belichaevsk; 27 - Zimnyaya Stavka (Zimne-Stavkinsk) 28 - Ozek-Sautsk; 29 - Northern-Stavropol; 30 - Kazinsk and Grachevsk; 31 - Perovsk; 32 - Blagodarnensk; 33 - Dovsunsk; 34 - Chkalovsk; 35 - Praskoveisk and Pravokumsk; 36 - Kosyakinsk; 37 - Sengileyevsk; 38 - Yankulsk; 39 - Northern Nagutsk; 40 - Nadzorneisk; 41 - Aleksandrovsk.

the platform slope more and more. Against the background of a general subsidence, separate zones underwent relative uplift or relatively smaller warpings.

The question concerning the borders of the Terek-Caspian foredeep is of basic significance. On the map of most recent movements its northern boundary is drawn along the 1000 m isobase from which we note that both north and south there are major changes in the thickness gradients of Upper Maikopian sediments. We believe that the natural limitation of the warping is the zone of the Kumsk uplift of platform type (Ozek-Suatsk, Velichayevsk, Zimnyaya Stavka and others). Within these limits the magnitude of recent movements is only a few dozens or hundreds of meters.

The juncture of the Terek-Caspian foredeep with the Stavropol uplift occurs, as it seems, along a flexure which might, in some places, he complicated by faulting. Boreholes drilled on the eastern outskirts of the Stavropol uplift and in the adjacent part of the Terek lowland indicate a sharp difference in the position of the cover of Maikop deposits. This shows on the map of most-recent movements, where a 1000 m isobase in the zone of frontal warping comes close to isobases 0 and + 100 m in the Stavropol area.

The Stavropol structure experienced tectonic movements of different directions in the latest time almost everywhere. Yet uplift was predominant, especially during upper Pliocene and Quaternary. At the same time the most recent tectonic movements were not irregular: some sections were rising comparatively stronger, others were rising less. Three rows of local uplifts are noted against the background of the generally-arched latest elevation of Stavropol to the north of the Mineralovodsk protrusion; these differ from the directly adjacent sections through relatively greater magnitude of recent positive movements and they form a line of complex arches, stretching WNW-ESE. The uplifts of the southern range of north-Nagutsk (Yangulsk, Sengileyevsk, Kosyakinsk) stretching along the southern part of Stavropol are notable for the great magnitude of tectonic movement in the latest stage. On the map of recent movements they are drawn as positive 500-600 m isobases. The second range coincides approximately with the middle part of Stavropol from the North-Stavropol, Kazansk, Grachevsk, Petrovsk and Blagodarnensk elevations. The extent of uplift changes here from 400 m in the west (North-Stavropol uplift) to 100 m in the east (Blagodarnensk). The third range consists of the Bezopasnensk-Kugultinsk, Ipathovsk and other uplifts stretching along the northern part of Stavropol and marked by isobases from 150 m to 0. To the north of this zone we observe a gradual transition to the zone of the Manych warping. Thus, we observe within the limits of Stavropol a regular decrease in magnitude of regional uplift (for the Middle Miocene-Quaternary) from south to north, from the Caucasus mountain structure to the Manych warping.

Throughout the Mid-Stavropol zone to the east, in the lowland Nogaysk steppe is a row of uplifts in the southern Kumsk region (Budenovsk, Pravokumsk, etc.) and, on the southeastern flank of the Kugultinsko-Ipatovsk zone, the northern-Kumsk group of elevations is located (Ozek-Suatsk, Velichaevsk, Zimnaya Stavka, etc.), which characterize the latest stage as having relatively smaller warpings as compared with adjacent regions.

The Manych uplift north of the Stavropol uplift and dividing the latter from the Yergeni uplift, is distinctly marked morphologically as a valley where eastern and western Manych are situated. In the neotectonic stage it served many times as a strait between the basins of the Black Sea and Caspian Sea. In Manych structure, Cretaceous, Tertiary and Quaternary deposits are found, reaching a thickness of about 3000 m, which differs considerably from the Terek-Caspian foredeep, where Upper Maikop deposits are over 4500 m thick.

The Manych zone is a type of warping of a platform with a relatively small total thickness of recent (Maikop) deposits, ranging, from 250 to 350 m. Their least thickness is in the Zunda-Tolga region which is characterized by its considerable narrowing of the valley of Manych, forming a producing structure between Eastern and Western Manych. The Maikop sediments increase in thickness occurs on the side of Manych-Tudilo and to the side of the Near-Caspian lowland. The total movement in the area of greatest subsidence near the axial part of the Manych basin (Lake Manych-Gudilo) does not exceed 300-350 m, which is shown on the map. The transition from the zone of subsidence to the zone of uplift (Stavropol in the south and Yergeni in the north) is nonuniform. Southward towards the Stavropol uplift, the extent of downwarp decreases quite gradually, and the zero isobase, contouring the depression borderlines, stretches over a distance of 40-50 km from the axis of downwarp; in other words, the rock dip here is about 5 to 7 m per kilometer. Northward, toward the Yergeni uplift, the transition is much sharper and the zero isobase extends only 15 to 20 km from the center of the Manych basin. The Maikop clay surface here dips from 10 to 15 degrees. These data on recent summary tectonic movements stress once more the asymmetry of the Manych downwarp. Yet this is much less evident in the more recent than in the older sediments.

The development of the western part of the northern Caspian area, north of the Manych depression, was quite complicated in the middle

Miocene and Quaternary. Its features were characterized by a constant succession of uplift and subsidence. It must be stressed that, as a result of intensive rising pre-Akchagylian tectonic movements, characteristic not only of the Caucasus and the Ciscaucasus, but also for the major part of the Russian platform, the whole western part of the northern Caspian area has risen and become land. This time corresponds to the formation of a strongly dissected relief, the making of deep erosive cuts along the Volga and Kama valleys, in some places as deep as -300 and -350 m and extensive erosion of previously accumulated sediments.

A general sinking of the region which continued until the end of the Khvalynian period began with the Akchagylian. During this time a complex of Akchagylian, Apsheronian, Bakinsian, Kharzarian and Khvalynian marine sediments were deposited. This is clearly indicated by the presence of different facies in almost every stage, as well as by the transition from marine to continental sedimentation. These transitions are noted not only at the ends of the stages but within them as well, indicating abrupt shifting between uplift and subsidence. This, we believe, occurred in the Pliocene, specifically during the Bakinsian, Khazarian and Khvalynian time. A. A. Bogdanov [2, 3] gave interesting data pertaining to the Pliocene, describing the Astrakhan borehole. He records alternation of the marine series with terrestrial swamps deposits. Many (G. I. Goretsky, P. V. Fedorov, M. V. Karandeeva, etc.) have pointed out analogous periodic marine-terrestrial shifts during the Quaternary.

We see that the rising of the earth's crust alternated many times with considerable subsidence in the western part of the Prikaspiyskaya [Near-Caspian] Nizmennost' during middle-Miocene and Quaternary. The main characteristic of these movements was their widespread axial distribution. Against the background of a general subsidence regularly-developing warping, sections of relatively smaller more intense subsidence or even uplift, are noted. A summary statement on recent tectonic movements in the western Near-Caspian must emphasize both uplift and subsidence in the several local areas.

In the evaluation of recent tectonic movements for the middle Miocene and Quaternary in the western Near-Caspian and in determining their effect in present day relief, a very interesting regularity has been noticed. On our map (see fig. 1) of this area, we note a zone which stretches from the southern Yergeni east-south toward Promyslovka village; this is the eastern part of the Don-Caspian arch. Against the background of the primary sinking of the other part of the Prikaspiyskaya Nizmennost' this zone stands out because of its predominance of recent tectonic uplift to considerable magnitude. It was especially intensive in the region of the Yartinsk uplift (near the Peschanoye village), situated in the vicinity of the juncture of the Yergeni upland with the Prikaspiyskaya Nizmennost'. Drilling has revealed Lower Cretaceous in the arched part of this uplift; they are covered with a small layer of Khazarkian and Khvalynian deposits. South and north of the Upper Cretaceous arch deposits are found rocks of Paleogene, [Paleogene=Paleocene-Oligocene and Maikop age] at least 1,000 m thick (fig. 2). Such thickness and regularity in distribution of these sediments indicates a long period of development of the Yartinsk uplift in post-Maikop time. During this growth process, considerable erosion of Maikop, lower Paleogene and upper Paleogene deposits occurred. It seems that uplift took place here almost during the whole period of the latest tectonic stage in question. Nor do we exclude the fact that at times uplift alternated with subsidence, yet a positive component was of obvious predominance. An appraisal of the cumulative elevation value for the latest tectonic stage can be made by using the thickness of the deposits, eroded in the post-Maikopian. Assuming that on in areas of uplift the rate of sediment accumulation is decreased, let us take for the arched part of the Yartinsk fold the thickness of eroded Maikop, middle Paleogene, lower Paleogene, Upper Cretaceous rocks of about 500 m, which makes almost half of the total thickness of the deposits on the margins where they are widespread. We believe that it is not possible to assume a greater thickness gradient (from local elevations to the downwarps) under platform conditions. Thus, the summary effect of recent tectonic positive movement in the central part of the Yartinsk elevation is on the order of 500 m and 300 to 200 m on margins.

East of the Peschanoye village along the Don-Caspian arch, in the Miocene and Pre-Akchagylian, considerable uplift also occurred, accompanied by intensive erosion of Maikop and, in some places, lower Paleogene rocks. As a result, in the Promyslovka village region, Upper Cretaceous deposits were found on the pre-Akchagylian surface, and Paleogene deposits were found in the regions of the Tsybuksk village and Olenichevo. But the subsequent history of tectonic development of the eastern end of the Don-Caspian arch and its Yergeni section was different. If the latter experienced mostly positive movements until the Quaternary time, then the region of the Promyslovsk elevation and of the adjacent Olenirebsk and Tsubuksk was, from the beginning of the Akchagylian, drawn into a north-south sinking which included at that time the Near-Caspian syneclise.

An analysis of distribution of Akchagylian, Apsheronian and Quaternary deposits shows regular increase in thickness from 100 or 150 m on the eastern wing of the Yartinsk elevation to about 410 or 450 m in the Promyslovka region,

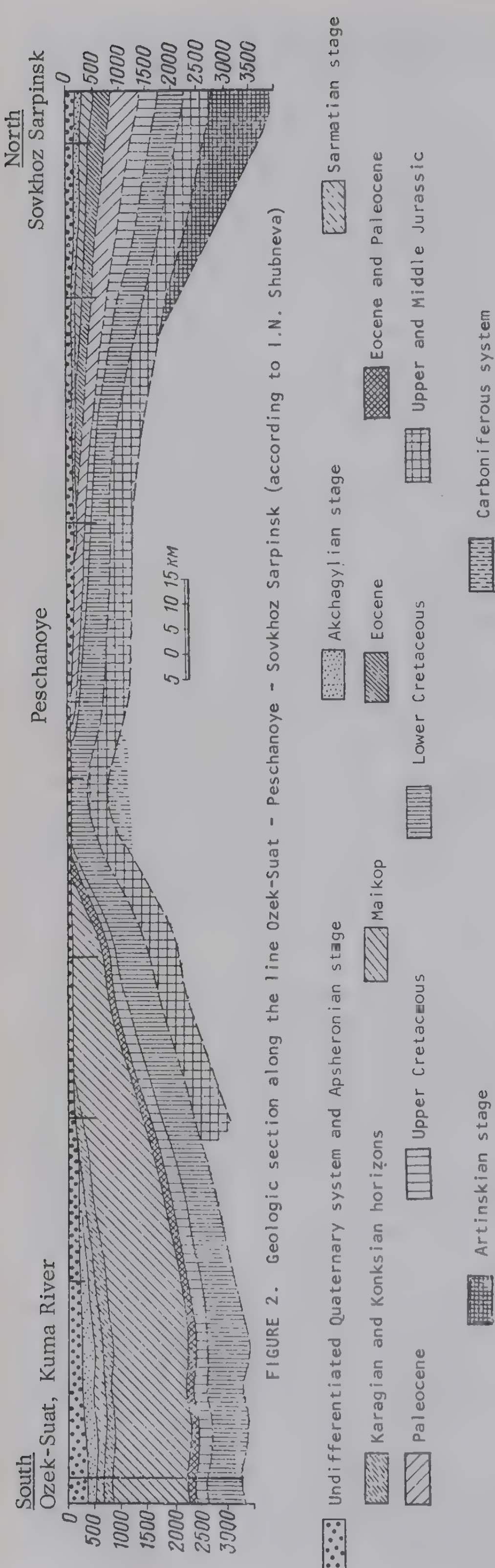

FIGURE 2. Geologic section along the line Ozek-Suat - Peschanoye - Sovkhoz Sarpinsk (according to I.N. Shubneva)

that is from east to west. Such variation in sediment thickness indicates a difference in occurrence and magnitude of the latest tectonic movements in different sections of the zone in question.

The most intensive warping during the Pliocene-Quaternary occurred in zones directly adjacent to the present-day Caspian Sea.

If we compare data on the thickness of eroded strata during periods of intensive pre-Akchagylian uplifts with the magnitude of subsidence during Pliocene-Quaternary, we conclude that, in the region of the Promyslovka river, uplift prevailed in the latest stage of tectonic development. Thus, in the region of the Prikaspiyskaya Nizmennost' with its characteristics of absolute heights from 0 to -25 m according to geological data, a zone of primary recent elevations stands out, which is especially considerable in the Yarta (Peschanoye village) region.

As we know, actively developing geologic structure is reflected in the surface relief depending on the degree of intensity of tectonic movements and type of exogenetic processes. Intensive erosion, which occurred in the western Near-Caspian during separate stages of its recent tectonic development, and repeated marine transgressions were destroying the arched parts of active uplifts. That the deposits consisted of mostly loose, easily eroded rocks also aided erosive processes. Only through a detailed study of the micro- and macrorelief, formed mainly in the late Khvalynsian and Post-Khvalynsian, can we find morphologic traits to indicate the nature of tectonism.

The line of uplifts of the South Yergeni is a direct continuation of the Promyslovsk-Sartinsk zone to the west-northwest. The maximum extent of the latest regional tectonic movements coincides with the Beloglinsk, Manych and Remontnensk uplifts, which are marked on the map by isobases from +500 to +400 m. As we see, the total uplift these latter movements approximates similar uplift in the Yartinsko-Peschany region of the Near-Caspian. A zone of recent tectonic movements of lesser magnitude is located between them. We get the impression of a succession of north-south waves of larger and smaller uplift. The Zimovnikovsko-Yashkulsk downwarp, outlined by a zero isobase and bounded on the northeast by the Kotelnichesko-Ovatinsk line of uplifts, is shown on the map north of the South Yergeni. It is impossible that the Astrakhan downwarp of the Caspian is the east-southeast continuation of the Zimovnikovsko-Yashkulsk downwarp of the Yergeni and that the Astrakhan-Tinaksk uplifts, which show a relatively lesser warping against the background of general sinking is the continuation of the Kotelnichesko-Ovatinsk zone.

An ancient Precambrian platform stretches

north of the Astrakhan-Tinaksk line of uplifts. Repeated change between uplift and subsidence were characteristic for almost the entire territory although the subsidence was of primary importance. The isobases alternate here from zero in the Yergeni section to -400 and -500 m in the Volga region. Against the background of these large regional subsidences, which include waste territories of the Prikaspiyskaya Nizmennost', there are local areas of sections of relatively more intense sinking and, in some places, recent uplift. This is clearly discernible near Sarpinsk, where, in its arched part Cretaceous rocks are found under Pliocene-Quaternary deposits. It seems that these uplifts appeared as a result of the salt-dome development, well developed in the Prekaspiyskaya Nizmennost'. Probably irregular tectonic movements and different degrees of warping of separate Near-Caspian regions contributed to the growth of salt domes in recent times.

Thus, the territory under study, which is structurally complex, was in the latest stage of its tectonic development (middle Miocene-Quaternary) a region of distinctly defined differentiated movements. The Stavropol and Yergeni massifs mainly experienced uplift, while sinking prevailed in the western part of the Near-Caspian syneclise, in the Manych basin and in the eastern Ciscaucasus. Sinking of especially great magnitude took place in the Terek region where, during Neogene-Quaternary a large foredeep was forming in the young Epihercynian (Scythian) platform.

An alternation of uplift with subsidence could be observed at times within these basic structures, yet this did not substantially influence the general tendency of their recent development, which determined the main features of contemporary relief.

The definition of local uplifts in the relief is also different. Within rising zones these are sections of most energetic elevations and in regions of subsidence they are only relative uplifts, as compared with the general pace of sinking. Our analysis of most recent tectonic movement shows some deviations from the general terrain in the western part of the Near-Caspian; where, in areas of relative monotony some areas of uplift stand out. This is clearly evident in the Yartinsko (Peschano) Promyslovsk zone where recent uplift is comparable to that of the south Yergeni and Stavropol local uplifts. No doubt, previous structure influenced the formation of the latest structure in the described area. In a number of cases the general plan of distribution of separate zones and local uplifts follows the plan of older, pre-middle Miocene structural elements. In the process of recent tectonic development only some changing of form was noticed (in some places an alternation of axes of uplifts and downwarps) which nevertheless did not substantially alter the general structural plan.

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MINERAL WATERS OF BOHEMIA[1]

by

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REVIEWER'S NOTE

This paper presents some interesting data on mineral waters of a well known region of spas and health springs. The paper is significant because it allows comparisons of mineral waters in Bohemia with those of other better-known areas elsewhere on which there are much published data. A valuable little paper.

ABSTRACT

Mineral waters of Bohemia are characterized by a considerable variety of chemical gaseous composition. They may be subdivided chemically into: calcium bicarbonate, sodium bicarbonate, magnesium sulfate, sodium sulfate, and ferruginous sulfate. Carbonated-water springs are chiefly developed along the periphery of the Bohemian massif. The conditions of formation of such springs in Karlovy Vary, Františkovy Lázně and Mariánské Lazně and Lugačevice are highly distinctive. Hydrogen-sulfide waters are widespread along the eastern margin of the region, forming part of an extensive zone of oil-bearing waters stretching from Austria into Czechoslovakia and Poland. The principal chemical types of hydrogen sulfide waters are the sodium bicarbonate and calcium bicarbonate varieties. Waters of Bohemia are distinguished according to the degree of radioactivity, low-, mean-, and high-radioactive. The greatest number of radioactive springs has been found on Rudná Hora, the Sudeten, the Slavkov Forests, Central Bohemia and Bohemian Moravian Hills.

Bohemia's mineral waters are widely used for medicinal purposes. --Author's English Summary.

* * *

Approximately 650 mineral springs in Czechoslovakia are used for medicinal purposes. The greatest number are located in western Bohemia, in the Jeseniki Mountains and near the inner zone of the Slovak Carpathians. The following mineral water health resorts are well known abroad: Karlovy-Vary, Mariánské-Lázně, Františkovy-Lazně and Lugačevice.

Bohemia is bordered by mountains on three sides: on the northeast by the Sudeten, on the northwest by the Rudná Hora and on the southwest by the Bohemian Forest and the Sumava. In the east and southeast are the vast Bohemian Hills. Bohemia has a rather dense river network but there are no rivers on this territory that are particularly long or copious. This is due to its position in the center of the European continent in the main European interstream area. The main water arteries are the Elbe with its tributary Vltava, the Morava and the Odra [Ohře?]. The climate of Bohemia is temperate-continental and is formed mainly under the influence of air-masses moving from the Atlantic ocean.

GEOLOGIC-STRUCTURAL FEATURES

Czechoslovakia has two main geological structures: the Bohemian massif and the Carpathian folded region. The border between them passes through the cities of Znoimo, Brno, Prserov, Granice and Ostrava. The Bohemian massif occupies the greatest part of this region and adjoins the Carpathian flysch zone to the east.

The Bohemian massif is an ancient folded structure consisting of Caledonian folds overlain by the Hercynian. The central part of the massif and its pre-Hercynian formations of Saxony-Thuringia, West-Sudeten and Moravia-Silesia fall within Bohemia.

This includes the Bohemian-Moravian Hills, the Brdy range, the Sumava Mountains, the Bohemian Forest, the Slavkov Forest Hills and Mt. Rudná Hora. Its most ancient zone is the Moldava-Danube, which outcrops as strongly metamorphosed rocks (gneiss, crystalline schist, etc.), which are interrupted in some places by large granite massifs. Somewhat less metamorphosed deposits are observed along the northern border of the Bohemian-Moravian Hills and in the regions of Kutná Hora, Brdy, Slavkov Forest and Rudná Hora. Here we find outcrops of gneiss, crystalline schist, phyllite, sandstone, shale and limestone with Hercynian granite intrusions. These rocks belong to the Proterozoic-Devonian.

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[1] Translated from Mineralnye vody chekhii: Sovetskaya Geologiya, 1960, No. 8, pp. 102-114.

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The Saxony-Thuringia province covers a small area in northwestern Bohemia and consists of Cambrian phyllites.

The West-Sudeten region includes the mountains of Krkonos, Luzice, Jinzer, Orlic and Javornic. It is made of manifold metamorphic Precambrian and lower Paleozoic rocks; there are notable outcrops of intrusives of different ages.

The eastern part of the Bohemian-Moravian Hills, the Dragan Hills, the Moravian karst and Jeseniki belong to the Moravian-Silesian region. The rocks of this region consist of schists, limestones and of other Precambrian and lower upper Paleozoic deposits.

After the Hercynian folding the accumulation of sediments in the Bohemian massif occurred mainly in the Permian-Carboniferous, Cretaceous, Paleogene and Neogene. Depressions in the ancient basement of the Pilsen, Kladno, Trutnov, Rosice and Ostrava regions are filled with coal-bearing rocks of the Permian-Carboniferous. Upper Cretaceous sediments, represented by sandstones, schists, gaizes and marls, are spread through northern Bohemia along the Elbe river valley. Tertiary deposits are developed in the depression zone of Rudná Hora foothills, Bohemian Budweis and Tresebon. These are lacustrine-swamp often coal-bearing sediments.

During the Tertiary the Bohemian massif was divided into a number of blocks, many of which were uplifted or dropped. Later on, between the Oligocene and Miocene, even stronger tectonic movements, accompanied by volcanic activity, took place. The basic effusives (basalts, phonolites) are widely spread over the territory of the Rudná Hora foredeep and in North Bohemia. The marginal zone of the Carpathian Mountains in Bohemia is a foredeep filled with Magurian and Zhdanian flysch. Tectonic movements which manifested themselves especially strongly in the Neogene were accompanied by andesite and basalt intrusions. Bohemian geologists connect carbonic acid mineral springs with the Tertiary volcanic zone.

MINERAL WATERS

A variety of mineral waters of different types can be found on the relatively small territory of Bohemia; there are three basic groups among them: carbonated, hydrogen-sulfide and radonic springs (see map).

According to the conditions of their occurrence the Bohemian mineral springs can be classified as: interstitial waters, interstitial-stratum waters and interstitial-karst waters.

The following types have been classified according to their chemical constituents [29]: calcium-bicarbonate, sodium-bicarbonate, calcium-sulfide, magnesium-sulfate, sodium-sulfate and ferruginous-sulfate waters.

A description of separate groups of mineral waters and a selection of their most typical representatives follows:

CARBONATED MINERAL WATERS

The sources of carbonated-water springs are mainly confined to the periphery of the Bohemian massif. Their outlets form part of "belt of mineral waters" stretching from the Rhein-Schist Mountains in West Germany through the foothills regions of Rudná Hora and Krkonas to Silesia. The belt of carbonated water springs permeating the Bohemian massif, coincides with outcroppings of local Cenozoic extrusives.

From the geologic viewpoint, separate regions of northern Bohemia (Česká-Budjevice, Trsebon) are like those of Rudná Hora foredeep; yet there is no evidence of a Tertiary volcanism, which explains the absence [10] of carbonated mineral waters in this area.

The second large territory of carbonated mineral-water springs is the area where the Bohemian massif joins the Carpathian Mountains. Carbonated mineral waters, hydrosulfide and iodine-bromine springs, as well as other types are in this zone.

Carbonated waters have a great range of flow, temperature, basic mineralization and chemical content. The minimum flow of springs has been located in the region of Mariánské-Lázně. Maximum flow of carbonated waters, equaling 30L/sec, has its source at Vrzidlo (Karlovy-Vary).

The temperature of carbonated waters is basically defined by its depth of circulation, which ranges from several meters (Mariánské-Lázně and others) up to thousands of meters (Karlovy-Vary). Cold waters ($t° = 7-13° C$) are prevalent. The Teplice waters on the Becva river are warm ($t° = 22° C$), and the waters of the health resort Karlovy-Vary are hot ($t° = 40-73° C$).

There are waters of low mineralization (Vratislavice, Teplice on the Becva river, and others), and waters of heightened mineralization with from 5 to 24g/L solids (Frantiskovy-Lázně, Lugačevice and others). The mineralization of waters is determined by the circumstances and the time of its circulation, rocks composition and other factors. The ingredient CO_2, depending on the circumstances of formation and temperature, varies in concentration CO_2 0.4-g/L (Karlovy-Vary, $t° = 73° C$) and 3.5g/L (Vratislavice, $t° = 8$ or $9° C$).

The following types of carbonaceous waters can be isolated:

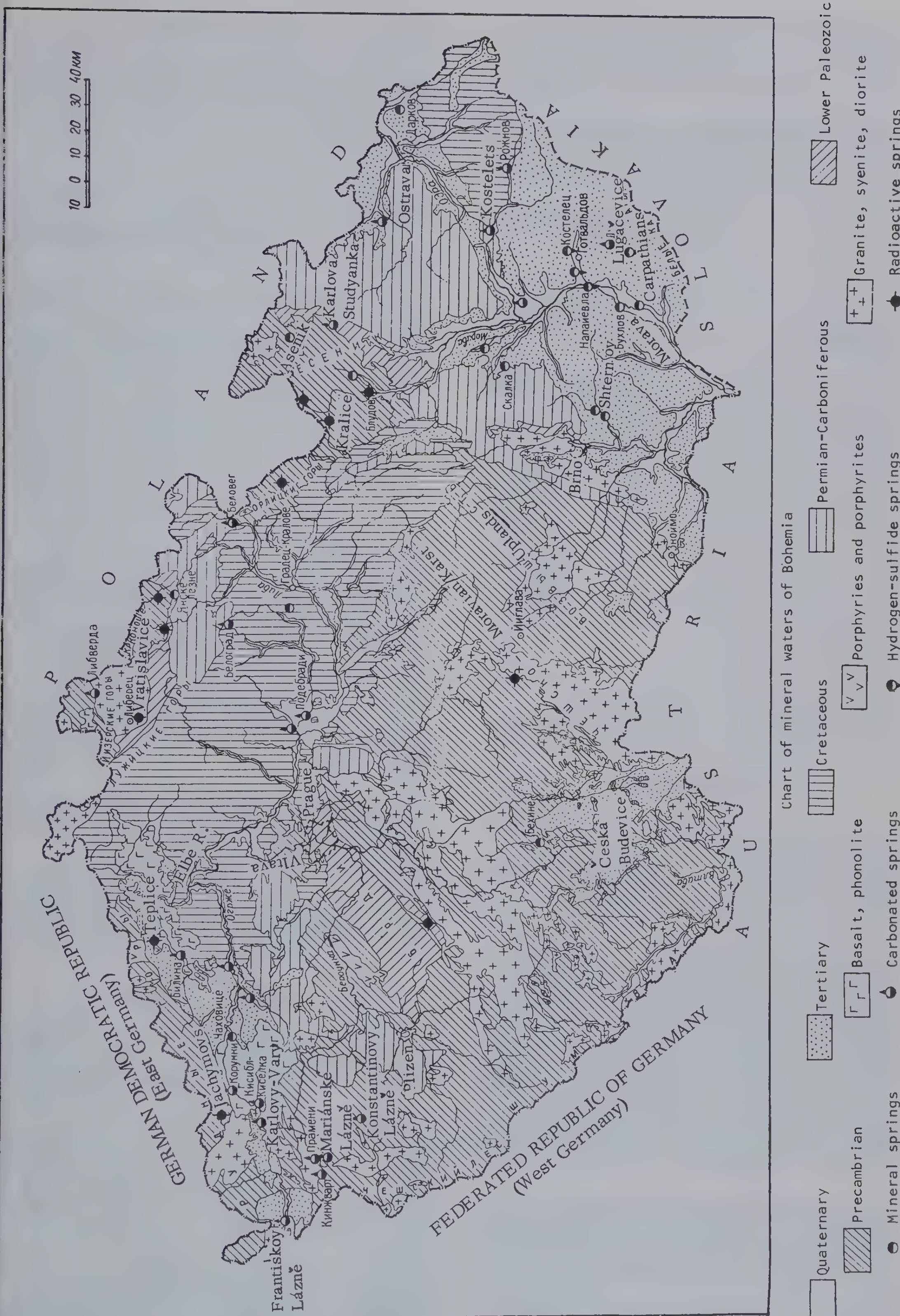

Chart of mineral waters of Bohemia

1) Mainly calcium hydrocarbonate waters, frequent in the regions of Mariánské-Lázně, Kinzvart, Karlovy-Vary, Podebrady, Nahod, Podlesy, Teplice on the Becva river and others.

2) Mainly sodium bicarbonate waters located in the regions of Mariánské-Lázně, Karlovy-Vary, Kisibl, Koruny, Bilina, Vratislavice, Podebrady, Lugačevice and others.

3) Sodium sulfate waters characteristic of Františkovy-Lázně and Beloves.

In the health resorts areas of Mariánské-Lázně and Karlovy-Vary are also chiefly sodium waters, hydrocarbonate-sulfate and sulfate-hydrocarbonate.

The genesis of the chemical content of waters, a complicated process, occurs either by leaching of rocks of different lithologic structure through the action of aggressive carbon dioxide, or by mixture of waters of different types (Karlovy-Vary, Mariánské-Lázně). The sodium-bicarbonate waters of the Podebrady and Lugačevice resorts, according to Vacslav Zika [25] were thus formed as a result of mixture of oil deposit waters of the calcium hydrocarbonate waters of infiltration origin. Czechoslovakian geologists and hydrogeologists explain the origin of CO_2 of carbonated subterranean waters as the result of postvolcanic processes [11] or of radioactive decay and of chemical reactions, in the earth's crust [9]. The first hypothesis is supported by the fact that the regions of young volcanism coincide with the area of carbonated springs.

Františkovy-Lázně

The Františkovy-Lázně resort is located on the northwestern margin of the Cheb lignite basin. In many sections of the region, especially to the north of the Ogrze [Ohře?] river valley, are carbonated-water springs.

The most ancient mountain rocks in this region are the Precambrian Cheb phyllites, whose upper part underwent kaolinization. Further up we find argillaceous-arenaceous and carbonaceous Miocene strata, covered with Quaternary deposits. The thickness of Cenozoic deposits is about 60 m. Granites of the Pintara Hora massif appear on the surface in the northern and western parts of the basin. Faults often connected with springs of carbon-dioxide waters and of dry CO_2 are at angles from a north-south direction.

The volcanism of the region was completed near the end of the Tertiary and the beginning of the Quaternary. The Komorny [Komárno?], Hurka and Zelezna basalt cupolas substantiate this.

The mineral waters saturate the poorly compacted, arenaceous layers of Tertiary deposits and the interstices in phyllites. Twenty-four sources of carbon dioxide waters are known in the region of Frantiskovy-Lázně. There are also outlets of almost pure CO_2 as well as medicinal mud on the Hayek section. Three types of mineral waters are characteristic for this region.

1) Sodium sulfate (Slaný, Liucny, Glauber springs):

$$Li_{0.099}\,CO^{2}_{0.9}\,M_{21.93}\,\frac{SO^{4}_{63}\,Cl_{21}\,HCO^{3}_{16}}{Na_{83}}\;T=13.1°C;$$

pH=8.1; Q=0.0015 L/sec. (Glauber spring – 4)

2) Sodium bicarbonate-sulfate (Frantiskovy and Natalia springs): Rn 10.2 em CO_2 3.07 M 2.28 SO

$$Rn_{10.2}\,CO^{2}_{3.07}\,M_{2.28}\,\frac{SO^{4}_{51}\,HCO^{3}_{25}\,Cl_{24}}{Na_{87}}\;T=10.2°C;$$

pH=5.9; Q=0.13 L/sec. (Natalia spring).

3) Ferruginous waters (Ozelovy spring).

Data on temperature, mineralization, CO_2 content and radioactivity of various springs belonging to this group are given in Table 1.

The general mineralization of springs belonging to this group occurring in crystalline rocks and in their residuum increases with depth. Some enrichment of waters with SO_4^{-2} occurs in Tertiary sediments rich in gypsum and epsomite. The total spring flow is about 1440 m^3/24 hrs.

Recently a number of wells have been drilled in the region of Františkovy-Lázně. Mineral water comes out of two boreholes with a 6.61 L/sec. flow; its CO_2 content is 0.4 g/L. The piezometric level is +10 m at the surface. There is a spring of almost pure carbon dioxide gas in the park at the resort.

TABLE 1

Name of spring	Water temperature in °C	Dry residue in g/L	CO_2 content in g/L	Radioactivity in ems
Slaný	10.12	4.89	1.21	29.3
Liucny	10.99	6.95	1.74	12.8
Novy	10.20	5.27	1.82	11.5
Ocelovy	12.5	3.19	3.08	12.3
Studene Vrzidlo	11.44	6.06	3.07	25.0
Františkovy	10.50	5.49	2.42	30.0
Lužnice	10.87	4.90	2.50	-
Loumanuv	10.35	4.30	1.81	10.3
Stepencin	10.50	1.91	2.35	11.2
Herkuluv	10.90	2.05	2.37	11.5

Mariánské-Lázně

The health resort of Mariánské-Lázně is situated in the southwest margin of the Slavkov Forest Hills. There are several dozen carbon dioxide springs here.

Mountain rocks in this region vary in lithological structure and age. Prevalent are Proterozoic and lower Paleozoic schist, gneiss, phyllites and amphibolites, upper Paleozoic granites, and Upper Tertiary basalts.

The main faults extending from northwest to southeast are related to Hercynian folding. Outstanding is the Slavkov Forest fault which separates the Slavkov Forest massif from the Plana valley (drop of 300 m) and includes the southern part of the Mariánské-Lázné region. The north-south faults are younger than the Hercynian (Alpine). They were formed at the end of the Tertiary and the beginning of the Quaternary, in other words, simultaneously with the occurrence of volcanism in west Czechoslovakia.

Springs of carbonated mineral waters are confined to north-south-trending faults. They are tapped by small (up to 27. 5 m) wells. The regime of the springs shows their close relation to atmospheric sediments. The total flow of carbonated waters ranges between 5. 6L and 7. 2L per/sec.

The temperature of carbonated waters is 2 to 3° higher than the average annual temperature in the Mariánské-Lázné region, or approximately 7°.

According to their chemical content carbonated waters are divided into five groups [10].

1) Sodium bicarbonate-sulfate (Krestovy spring):

$$Rn_{15.5}\,CO^{2}_{2.21}\,M_{10.21}\frac{SO^{4}_{46}HCO^{3}_{33}Cl_{21}}{Na_{94}}T=75°\,C.$$

2) Sodium sulfate-hydrocarbonate (Lesny spring):

$$Rn_{16.7}\,CO^{2}_{2.45}M_{3.99}\frac{HCO^{3}_{56}SO^{4}_{33}Cl_{11}}{Na_{90}}T=10°\,C.$$

3) Magnesium-calcium hydrocarbonate (Rudolf spring):

$$Rn_{4.0}\,CO^{2}_{2.05}M_{2.50}\frac{HCO^{3}_{95}}{Ca_{46}Mg_{31}Na_{23}}\,T=9.4°\,C.$$

4) Iron magnesium-calcium-hydrocarbonate and calcium sulfate-hydrocarbonate with general mineralization of 1. 3-4. 5 g/L and CO_2 = 2. 29 g/L (Ambrozovy springs).

5) Calcium hydrocarbonate (Maria spring):

$$CO^{2}_{1.95}\,M_{0.17}\frac{HCO^{3}_{91}}{Ca_{93}}T=10.7°\,C.$$

The difference in chemical content of waters is due to a complicated (lithology) of rocks and to the conditions of water formation.

Data on other springs of the Mariánské-Lázné resort are given in Table 2.

Table 2

Name of spring	Water temperature in °C	Dry residue in g/L	CO_2 content in g/L	Radioactivity in ems
Ferdinand	10. 3	10. 17	3. 18	2. 4
Alfredov	8. 2	7. 27	2. 17	3. 8
Alexandrin	8. 4	6. 43	2. 18	4. 1
Liucny	8. 25	2. 44	2. 17	-
Ambrozum	9. 6	1. 34	2. 29	5. 9
Karlin	8. 8	1. 66	2. 96	4. 8
Lazensky	8. 7	1. 19	2. 43	-
Prelatcky	8. 3	0. 84	2. 59	-
Excelsior	7. 8	0. 66	2. 81	-

Karlovy-Vary

Among all the Czechoslovakian health resorts the most popular is Karlovy-Vary. Hot carbonated waters of the health resort surface in the Tepla River valley near its falling into the Ogrze river.

Oldest formations of this region are upper Proterozoic and lower Paleozoic gneiss, crystalline schist and phyllites, broken by Variscian granites of the Eibenstock-Karlovy-Vary massif. Two basic types are significant – the Karlovy-Vary and Mt. Rudná Hora. Karlovy-Vary porphyry biotite granites are older than the Rudná-Hora heteromorphic biotite-muscovite granites. Granites of the upper zone, especially of its zone of spalling, weathered into kaolin 50 m thick. The subsidence of the Rudná-Hora foredeep region occurred in the Tertiary. At this time lignite-bearing sediments accumulated to a thickness of several hundred meters and basic lava flow also occurred. Aragonite deposited by mineral waters in the Tepla river valley reaches 10 m in thickness.

Ten springs are flowing in Karlovy-Vary at the present time; they surface through a system of parallel faults cutting through the Rudná-Hora granites toward the north-northwest and south-southeast. The zone of artesian water heads runs through the river valley for 1325 m. The water (with a temperature up to 73°) issues

from a depth of about 2,000 m.

The largest spring: Vrzidlo (Sprudel) is situated on the right bank of the Tepla River. Its flows at 30 L/sec., the head reaching 15 m above the surface.

Ostal spring exits on the left bank of this river. It flows at 3 L/sec. at temperatures ranging from 40 to 73°.

A. M. Ovchinikov [5] assumes that hot waters rise through faults from the northeast, and that an influx of colder waters from the southwest occurs which creates a hydrostatic pressure and also slightly dilutes the hot waters.

Carbonated waters are of the sodium-sulfate-bicarbonate type. The chemical content of Vrzidlo spring waters is, according to Kurlov, as follows:

$$Rn_{3.6}F_{0.002}Li_{0.003}H^{2}SiO^{3}_{0.094}CO^{2}_{0.4}M_{6.4}$$

$$\frac{HCO^{3}_{40}SO^{4}_{40}Cl_{20}}{Na_{88}Ca_{7}Mg_{5}}T=73°\ C;\ pH=7.07.$$

The chemical content of the small springs is like that of the Vrzidlo spring waters (table 3, after A. M. Ovchinikov, 1955).

The waters carry off about 18 tons per 24 hours of the well known Carlsbad salt.

Podebrady

The health resort Podebrady is situated in the Elbe River valley 53 km to the northeast from Prague. The cold carbonated waters of Podebrady are tapped by 18 artesian wells 87 to 142 m deep.

Under Quaternary deposits, represented by sandy alluvial deposits of the Elbe river several meters thick, Turonian marls occur to serve as an impermeable factor. Further down are Cenomanian aquiferous sandstones about 20 m thick. Permian shales and sandstones about 30 m thick and slightly permeable underlie the Upper Cretaceous. Permian strata overlie phyllites of the Hercynian crystalline basement.

Artesian waters appeared saturated with free carbon dioxide at the outcrop of Cenomanian sandstone. Gushing flows of carbonated waters are confined to intersections of faults of the northwest-trending faults with younger ones of the north-northeast strike. Northwestern trending faults occurred in the Hercynian and were renewed during Upper Tertiary volcanic activity, which manifested itself in the form of eruptions of basalt lava.

The chemical content of waters emerging by artesian wells is as follows:

$$CO^{2}_{2.62}M_{3.66}\frac{HCO^{3}_{71}Cl_{26}}{Na_{57}Ca_{27}Mg_{16}}T=12-13°\ \text{(well 1).}$$

Spring flow of Podebrady mineral waters is 700 m^3/ 24 hrs. The replenishment region of mineral waters is situated [10] on the southern wing of the North-Bohemian Cretaceous basin.

Carbonated waters are also known in other regions of the basin: Nimburk, Sadsko, Belograd and others.

TABLE 3

Name of spring	Chemical content according to Kurlov	pH	Spring flow in L/sec.
Melnicny	$CO^{2}_{0.65}M_{6.21}\frac{HCO^{3}_{40}SO^{4}_{39}Cl_{21}}{Na_{89}Ca_{7}}T=50.9°\ C$	6.89	0.034
Parkovy	$CO^{2}_{1.0}M_{6.32}\frac{HCO^{3}_{40}SO^{4}_{40}Cl_{20}}{Na_{89}Ca_{7}}T=46.2°\ C$	6.6	0.231
Skalny	$CO^{2}_{0.97}M_{6.25}\frac{HCO^{3}_{41}SO^{4}_{39}Cl_{20}}{Na_{89}Ca_{7}}T=52.5°\ C$	6.7	0.070
Vazlava	$CO^{2}_{0.8}M_{6.2}\frac{HCO^{3}_{40}SO^{4}_{40}Cl_{20}}{Na_{89}Ca_{6}}T=58.9°\ C$	6.8	0.266
Libuse	$CO^{2}_{0.84}M_{6.3}\frac{HCO^{3}_{41}SO^{4}_{39}Cl_{20}}{Na_{86}Ca_{8}}T=39.5°\ C$	6.8	0.077

Teplice on the Becva River

Warm carbonated waters of the Teplice resort on the Becva River are an example of mineral waters which circulate through karst cavities. Karst mineral waters in the Bohemian massif are rare, while in the Carpathian Mountains a considerable number of well known mineral springs belong to this type.

Carbonated waters of this region surface where the Becva river cuts into Devonian cavernous limestone, which comes out from under younger rocks of the Lower Carboniferous, the Tertiary and the Quaternary. A considerable flow from Teplice springs 10 L/sec. — is observed to be related to an extensive karst zone of water replenishment. The tapping of carbonated water is accomplished by two wells which are 60 and 143 m deep.

The mineral content of the calcium-hydrocarbonate waters is:

$$Fe_{0.013}\,CO^{2}_{2.3}\,M_{1.6}\frac{HCO^{3}_{95}}{Ca_{84}Mg_{13}}\,T=22.8°$$

Vačslav Zýka explains the origin of CO_2 with late Tertiary volcanism, which manifested itself most intensively in the Brunntal region. Migration of CO_2 occurs along the fractures of the zone where the Bohemian massif joins the Carpathian Mountains.

Lugačevice

The Lugačevice mineral waters are developed in the flysch region of the Carpathian border zone. The spa is located in the Olsava River valley, on the northwestern slope of the White Carpathian mountains. There are flows from ten carbonated and one hydrogen-sulfide spring, all confined to Eocene limestones.

The rocks are broken by the Nezdenician fault, trending away from due north-south. Flysch sediments of the Lugačevice region are cut by Upper Tertiary andesites. Carbonated waters here are cold, ranging from 8° to 12° C; their chemical content is sodium chloride-bicarbonate [26], with mineralization of 6 to 12 g/L (table 4).

Mineralization content of the hydrogen sulfide spring water is 0.4 g/L. Its chemical content is of the calcium hydrocarbonate-type. Its H_2S content equals 2.5 mg/L and its CO_2 content is 58.4 mg/L. The oxidation-reduction Eh of the waters equals 204 mv.

Besides, carbonated waters have been found in the Gottwald zone, Lugačevice, also in in Zagorovice, Nezdenice, Brzezove and in other places. Hydorgen sulfide waters prevail in this zone. Their description follows.

HYDROGEN SULFIDE WATERS

The eastern border of Bohemia with the foredeep of the Carpathian Mountains – filled with Tertiary sediments – is rich in hydrogen sulfide springs. This area is part of an extensive zone of oil reservoir waters stretching from Austria into Czechoslovakia and Poland. Many hydrogen sulfide springs are known in the Gottwald area [25], in the regions of Napajedla, Otrokovice, Malenovice, Kostelec, Lugačevice and others. H_2S concentration in waters ranges from fractions to 28.5 mg/L. The temperature of the waters is cold, 5° to 15° C; Total mineralization is 0.3-4.5 g/L.

The basic chemical types of waters are sodium-bicarbonate and calcium-hydrocarbonate waters. More of chloride, iodine and bromine are often observed in these waters when sulfate content is low. The pH ranges from neutral to alkaline. The Eh of hydrogen sulfide waters [26] is -41 to 287 mvs.

Different investigators give different explanations for the conditions of hydrogen sulfide water formation. Some of them believe the H_2S is a product of postvolcanic exhalations [16]; others assume that H_2S occurs through dissolution of salts and chemical reactions [11]; still others say that H_2S is formed by means of decomposition of oil deposits [26]. Most data supports the latter viewpoint.

The Napajedle spring is a typical example of hydrogen sulfide waters. Mineral waters emerge at the base of the right bank of the Morava River from Tertiary bituminous shales and limestones covered with detritus. Temperature

TABLE 4

Name of spring	Water temperature °C	CO_2 content g/L	Total mineral content g/L	Content in g/L									
				HCO_3^{-1}	SO_4^{-2}	Cl^{-1}	Ca^{+2}	Mg^{+2}	Na^{+1}	I^{-1}	Br^{-1}	pH	Eh, mv
Aloiska	10.0	1.24	9.6	3.048	0.069	2.492	0.129	0.025	3.822	0.0020	0.0050	6.77	-6
Electra	12.0	1.46	12.5	3.912	0.057	3.324	0.166	0.024	4.955	0.0033	0.0067	6.93	-32
Otgovka	8.0	1.04	6.1	2.214	0.023	1.757	0.064	0.047	2.695	0.0015	0.0035	6.65	-3
Vincetka	9.0	1.51	5.9	2.250	0.013	1.462	0.360	0.015	2.256	0.0013	0.0023	6.69	-15

of the water is constant at 9.8 to 10.1°.

The chemical content of Napajedle hydrogen sulfide water is sodium bicarbonate-chloride:

$$H_2S_{0.0285}CO^2_{0.184}M_{4.4}\frac{Cl_{48}HCO^3_{44}}{Na_{96}}$$

$$T=9.8°;pH=7.6$$

The Eh is -287 mv. The water's iodine content is 1.8 mg/L, its bromine content, 4.1 mg/L. Free carbon dioxide in heightened concentrations (up to 520 mg/L) is found in hydrogen sulfide waters of the Louky and Nezdenice regions. These springs are of great interest for balneological purposes [26].

RADONIC WATERS

A considerable number of radioactive water springs has been established on the territory of Bohemia during a period of research which started at the beginning of the 20th century and is still being carried on. Their greatest number is to be found in the Rudná Hora territory, the Sudeten, Slavkov Forest, Central Bohemia and the Bohemian-Moravian Hills.

Of the different types of radioactive waters [6] we give a characteristic only of radon waters, which are being used for medicinal purposes.

Subterranean waters are divided according to their degree of radioactivity into low-radioactive (36-180 ems), medium-radioactive (180-360 ems) and high-radioactive (over 360 ems) waters. [3] Low radioactive waters are used in Bohemia in considerably greater quantities than high-radioactive waters.

Radon-rich waters are classified as follows:

1) Radon waters of the erosion crust of acid magma rocks with higher clarke concentrations of radioactive elements (Jizerske Hora, Krkonose, Central Bohemia, etc.)

2) Radon waters of tectonic disruptions: a) of nitrogen hot springs (Teplice), b) of carbonated waters (Vratislavice), c) of waters connected with ore concentrations of radioactive elements (Jachymov).

Among different types are sodium bicarbonate, calcium-hydrocarbonate and calcium-sulfate waters.

The flow of radioactive springs of the erosion crust usually does not exceed 0.5 L/sec. The flow from faults reaches 35 L/sec. (Teplice). Radioactive waters of the erosion crust are cold; of those formed in fault zones there are warm ones (Jachymov) and hot ones (Teplice). Radonic waters in Jachymov, Teplice and in other regions are widely used for medicinal purposes. Their characteristics follow:

Jachymov

As we know, in 1898 Marie and Pierre Curie isolated two new elements from Jachymov uranic pitchblende – radium and polonium. In 1905 physicists Stepan Maier and Indrzih Mache ascertained a high radioactivity of pit-waters in Jachymov which from 1906 on were used for medicinal purposes.

The radioactive Curie spring has its outlet in Svornost mine shaft 530 m deep at the intersection of two veins bearing uranium and silver-lead ore. The uranium veins were formed in the Lower Permian after a granitic intrusion of the Eibenstock-Karlovy-Vary massif. Predominant minerals are calcite, quartz, fluorite and pitchblende (uraninite). The granites transect strongly gneissic Jachymov micaceous schists and phyllites, of the Precambiran. The Precambrian rocks, as well as the intersecting quartz porphyry breaking through them, are veined by ores. The latter, in turn, are breached by basalt.

The radioactivity of the Curie spring ranges from 1200 to 2400 ems in inverse proportion to spring flow, which varies from 1.16 to 1.5 L/sec. The water temperature is around 28°.

The sodium bicarbonate water generally has a mineral content of over one g/L. On its way from the artesian outlet to the bathhouse the radioactive water loses a considerable amount of its emanation. In Jachymov, mineral water containing 160-180 ems of radon is used for medicinal purposes. Certain explorations of Jachymov, made to classify uranium veins, uncovered strongly radioactive waters with radon concentration of ten thousands of ems, but their spring flow is usually small.

Teplice

The Teplice spa is situated on the southern slope of Mt. Rudná Hora. Hot radioactive waters issue from Permian porphyries, which pierce and overlie Precambrian gneiss. They in turn are overlain by calcareous gaize and sandstone, as well as by Tertiary coal-bearing deposits. Basalt intrusion occurred in the Tertiary. Mineral springs are confined to two faults formed during the initial stage of the Rudná Hora foredeep, which cut the porphyries. The Pravrzidlo spring is located on the southernmost fault, the Kameny and Gorsky springs on the northern – all hydraulically interrelated.

[3] In Czechoslovakia springs containing radon in quantities exceeding 180 m [21] are considered radioactive waters.

The tapping of the springs at the present is through mine wells related to the drainage of mineral waters by coal mines [Dollinger (1879) and Victoria (1887)]. The ground-water level of Gorsky spring is about 19 m below the earth's surface. According to Kurlov, the formula of chemical content of the spring water is as follows:

$$Rn_{365.0}\,M_{0.6}\frac{HCO^{3}_{76}SO^{4}_{17}}{Na_{66}Ca_{26}}T=32.5°$$

The radon content is 300 to 365 ems, depending upon a flow ranging from 2 to 4 L/sec.

The Pravrzidlo spring has less radioactivity, but its flow is stronger and the temperature higher.

$$Rn_{36.4}\,M_{0.6}\frac{HCO^{3}_{74}SO^{4}_{15}Cl_{11}}{Na_{75}Ca_{18}}T=43°$$

During pumping, radioactive flow increases with the lowering of its level ranging between 12 and 35 L/sec. The Kameny spring in this region is also well known; its temperature is 29° to 30°, its radon cycle is 25 ems.

Springs of the Teplice river are typical examples of radonic waters of nitrogen thermae. The total spring flow of the Teplice mineral waters reaches 48 L/sec.

Vratislavice

The carbonated radon waters of Vratislavice surface on the southern slope of the Jizerske Mountains out of biotite muscovite granites of the Carboniferous. The spring is tapped through a shallow shaft.

The chemical content of the water is sodium-calcium-bicarbonate:

$$Rn_{240.0}\,CO^{2}_{3.54}\,M_{1.5}\frac{HCO^{3}_{94}}{Na_{64}Ca_{28}}T=8.9°.$$

The high radioactivity of mineral waters is explained by heightened content of radioactive elements along a zone of faulting in the Jizerske granite.

Radonic waters of the erosion crust of acidic magmatic rocks, of low or sometimes medium radioactivity, are widespread. A great number of radioactive springs also are known in the Jizerske and Orlicke mountains and in Krkonose, where radon reaches several hundred ems. In Jesenike there are dozens of springs with radioacitvity up to 200 ems. On the Bohemian-Moravian Hills between Jiglava (Iglau) and Pelgrzimova, waters up to 300 ems are found.

In the Prsibrana region springs have been measured at 400 and more ems.

The list of Bohemian mineral springs could be considerably extended. But over the few mineral springs of Bohemia mentioned prove the territory's richness in outstanding springs. The study of hydrogeologic conditions of foreign mineral water deposits will help Soviet hydrogeologists to heighten the resources of mineral waters of our country.

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This section is devoted to a listing of selected geologic items appearing in the two publications of the Library of Congress; Monthly Index of Russian Accessions, and East European Accessions Index. These lists are intended as a means of indicating to researchers in the earth sciences some of the material most recently available for screening, further review, and translation. For this reason the lists do not include material now, or soon to be, published in English. Emphasis is placed on Russian material; the extent to which items from East European sources are listed depends on the country and language involved.

A major function of the AGI translations program is the screening of foreign literature for material that should be made available to the English-speaking scientist. Researchers who need such material are urged to review these lists and send us their recommendations for consideration by the editors; the translation needs of all geologists will be served better thereby.

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Dislocations in the area of Malyy Atlym in the Ob' Valley. V.D. Nalivkin. pp. 256-266.

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Caledonian intrusives on the right bank of the Angren River. I.M. Isamukhamedov, A.A. Kustarnikova. pp. 3-10.
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Mechanism of the formation of erosion cavities in loess. A.S. Devdariani, S.D. Voronkevich. pp. 19-24.
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Some results of the geochemical study of Jurassic and Cretaceous oil- and gas-bearing sediments of the Kagan group. Kh.K. Ismatullaev. pp. 51-58.
Classification of petrographic provinces. O.M. Borisov. pp. 59-69.
Brucite marble in the Almalyk region. S.T. Badalov. pp. 70-72.
Wollastonite deposits in Uzbekistan. M.I. Ismailov. pp. 72-74.
"Paleogeography of Cretaceous oil- and gas-bearing sediments in Uzbekistan" by A.G. Babaev. Reviewed by A.G. Aliev, V.P. Akaeva. pp. 75-76.
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Ways of utilizing artesian wells in the semideserts of Kazakhstan. IU.I. Kirillov. pp. 58-60.

REFERENCE SECTION

RECENT TRANSLATIONS IN GEOLOGY

A Review of the Translation Services

Compiled by Amber Eustus

This part of the Reference Section is devoted each month to a listing of the new translations of geologic significance which have become available from sources other than IGR and the established cover-to-cover journals in geology and related fields. This is done to accomplish several purposes: 1) inform geologists of the foreign literature in their field available in translation; 2) provide information necessary to avoid duplication of translation effort, and 3) advise geologists of the activities of the various organizations providing translations or related services in their field.

COVER-TO-COVER TRANSLATION PROGRAMS

The National Science Foundation has issued a revised List of Russian Scientific Journals Available in English (August 1961, NSF 61-66). There are currently 120 of such journals, a total of six having ceased publication , usually because of a substitute program. The "Geological Sciences" and "Geochemistry" sectionsof Doklady, for instance, were replaced by the single "Earth Sciences Sections."

The NSF lists titles, both transliterated Russian and English translation, date of first issue covered by each program, frequency and number of pages published per year, translation agency, sponsor and subscription prices. The list includes those from English and Canadian sources.

The National Science Foundation is sponsor or co-sponsor of 48 of the journals at the present time. NSF's opposite number in Great Britain, the Department of Scientific and Industrial Research, is listed as sponsor or co-sponsor of 17 journals.

The 37 journals existing without such sponsorship reflect the fact in their higher per-page costs for annual subscription. Journals averaging 500 pages per year are offered at about the same price as IGR's non-member rate of $55 per year for 1,200 pages. The rate for AGI members is $15 per year.

MINERAL CLASSIFICATION

A new classification system for minerals is offered in the French-language, Repertoire alphabetique des mineraux. Indices de la "Codification des Fichiers bibliographiques." This project by the Bureau des Recherches géologiques et géophysiques et des minéres [Bureau of Geologic and Geophysical Research and Mining] can be useful even to those who do not read French, as the spellings of mineral names are the same in most cases. Exceptions are such common words as "albatre gypseax" for "gypsiferous alabaster" or "aegyrine" and "aegyrite" for "aegirine" and "aegirite."

Under the system, aarite, algodonite and arsennickel all fall in category A-214. The preliminary list was published in April; a revised list is to be completed. While somewhat useful in its present state, the minerals list would have to be used in conjunction with the parent "Codification des Fichiers bibliographiques" for full value.

"AL JIYŪLŪJY"

Serious efforts are being made in the Arab world, namely Iraq, to establish a geologic nomenclature in Arabic. The initial step is a magazine, Al Jiyūlūjy [The Geologist], published by the Geology Department of the University of Baghdad. Largely a student effort, the magazine contains articles in both English and Arabic. The editors make no claim of initiating important geologic literature; rather, they retrace familiar ground and describe well-known processes in their own language. The April 1961 issue, for instance, contains articles in Arabic on structure-contour mapping, construction materials and ground water of Iraq, petroleum geology in general, Algeria's petroleum (including some highly interesting statistics), and a glossary, the latter scarcely adequate for the announced purpose.

The AGI translations pool has the English version of two articles from the Arabic available in corrected draft form, with or without copies of the Arabic original. Copies of these translations will be supplied on the same basis as AGI translations from Russian (15 cents per page). The two are "Ground Water in Iraq" and "Scientific Field Trips." Page and cost data are included in the listing.

The translations were made by the author of this column, who seconds the comment of reviewer Douglas Alverson, "...much of the paper is simply a rehash of textbook material on geophysical methods applied to ground-water hydrology that have long been known to American hydrogeologists...." For anyone interested in keeping pace with one of the inevitable manifestations of nationalism, the new vocabulary might ultimately have value.

NEW RUSSIAN DICTIONARY

For readers of Russian only is the new Slovar' po gidrogeologii i inzhenernoy geologii [Dictionary on hydrogeology and engineering geology]. Compiled by A. A. Makkaveyev, it contains some 1,000 terms frequently encountered in these fields. It was printed by Goptekhizdat (2,000 copies); price is 0.85 ruble. Geologist-translators who have come to know the shortcomings of bilingual dictionaries will undoubtedly find this all-Russian compilation a pertinent addition to the bookshelf.

GEOLOGIC TRANSLATION JOURNALS

The following journals regularly contain translations of interest to geologists. Therefore, the subsequent list of recent translations does not include articles published in these journals:

Atomic Energy, published by Consultants Bureau.

Bulletin (Izvestiya) of the Academy of Sciences U. S. S. R., Geophysics Series, published by the American Geophysical Union.

Doklady of the Academy of Sciences of the U. S. S. R.,

Earth Sciences Sections, (Geochemistry, geology, geophysics, hydrogeology, mineralogy, paleontology, petrography, lithology and permafrost), published by the American Geological Institute.

Geochemistry, published by the Geochemical Society.

Geodesy and Cartography, published by the American Geophysical Union.

Izvestiya of the Academy of Sciences of the U. S. S. R., Geologic Series, published by the American Geological Institute.

Petroleum Geology, published by the Review of Russian Geology.

Problems of the North, published by the National Research Council of Canada.

Soil Science, published by the American Institute of Biological Sciences.

Soviet Geography, selected translations and reviews published by the American Geographic Society.

Soviet Physics: Crystallography, published by the American Institute of Physics.

MAJOR WORKS IN PROGRESS

"Recent Translations" reports on major works in the process of being translated, to prevent duplication of effort and to advise geologists of important works soon to become available. The following are being translated under the 1962 Program for Scientific Translations, financed by Public Law 480 funds. Only major works in progress are cited.

Ammosov, I. I., and Yeremin, I. V., 1960, Fracturing of coals [Treshchinovatost' uglei]: AN SSSR, Moscow, 108 pp. Being translated under Program for scientific translations 1962 (PL 480); reported Nov. '61, Israel.

Anonymous, 1960, Underground treatment of fuel [Podzemnaya pererabotka topliv]: Akad. nauk SSSR, Trudy, Inst. goruch. iskopaemykh, v. 8. Izd. AN SSSR, Moscow, 163 pp. Being translated under Program for scientific translations 1962 (PL 480); reported Nov. '61, Israel.

Khilmi, G. F., 1957, The theoretical biogeophysics of the forest [Teoreticheskaya biogeofizika lesa]: AN SSSR, Inst. fiz. zemli im. O. Yu. Shmidta. Izd. AN SSSR, Moscow, 202 pp. PST 698 PL 480, Israel, Nov. 1961.

Moldenskii, M. S., Ermeev, V. P., and Yurkina, M. I., 1960, Method of study of the external gravitational and figure of the earth: Being translated from Trudy, Tsentral. nauch.-issled. inst. geodezii, aero. i kartografii. Geodezizdat, no. 131, Moscow, 251 pp. Under PL 480/ reported Nov. 1961; Israel.

Shokin, P. F., 1960, Gravimetry, instruments and methods of measuring gravity: [Gravimetry, pribory i metody izmereniya sily tyazhesti]: Geodezizdat, Moscow, 313 pp. Being translated under PL 480, Nov. 1961, Israel. PST 644.

Strakhov, N. M., 1948, Essentials in historical geology [Osnovy istoricheskoi geologii]: Part I, 251 pp. Part II, 396 pp. Gosudarstv. Izd. geol. lit., Moscow-Leningrad. 647 pp. Being translated under Program for scientific translations 1962 (PL 480); reported Nov. '61, Israel.

SOURCES OF TRANSLATIONS

Lists of recent translations from which the following list was selected are:

Technical Translations, vol. 6, nos. 6 and 7.

AGI Translations Office

An index of sources and addresses will be found at the end of the list of translations.

Geologists and translators are invited to submit titles which have not been cited by services from which we compile these lists, together with information on where the translations may be procured. Submittal of a copy of the translation itself will be construed as an offer for IGR to publish, make copies available at cost of reproduction or consign it to a major translations repository at our discretion. Suggestions for improving this service are welcome.

RECENT TRANSLATIONS

Agroskin, A. A., 1961, Physical Properties of coal: Review of a book, Fizicheskiye svoystva uglya, Moscow, Metallurgizdat. 308 pp. 2,150 copies printed. BR-SOV/5219. 3 pp. ph $1.10.

Anonymous, 1961, Scientific field trips: Al Jiyuluji (Iraq), v. 2, no. 2, pp. 39-46 AGI. $1.05 English; $2.25 English and Arabic.

Anonymous, 1959, Hydrogeological conditions of Wuan coal fields and several problems which deserve attention in future prospecting work: in Hydrogeology and engineering geology, 1959, vol. 8: selected translations. Trans. from Shui Wen Ti Chih Kung Ch'eng Ti Chih (CPR), no. 8, pp. 1-37; no. 9, pp. 1-37; no. 9, pp. 1-42. JPRS 7877. OTS and SLA 61-23919. $19.75.

Anonymous, 1960, Application of electro-prospecting in hydrogeology and engineering geology work: in Hydrogeology and engineering geology, 1960, no. 4: selected translations. Trans. of Shui Wen Ti Chih (CPR), no. 4, pp. 3-8, 10-35, 37-39. JPRS 9356. OTS and SLA 61-27149. $10.10.

Anonymous, 1960, Introduction of a new method of long distance underground river connection experimentation: in Hydrogeology and engineering geology, 1960, no. 4: selected translations. Trans. from Shui Wen Ti Chih Kung Ch'eng Ti Chih (CPR), no. 4, pp. 3-8, 10-35, 37-39. JPRS 9356. OTS and SLA 61-27149. $10.10.

As-Sanawy, Sahil, 1960, Ground Water in Iraq: Al-Jiyulujy (Iraq), v. 2, no. 2, pp. 20-27. Trans. by Amber Eustus. AGI Translations Office. $1.05 (English); $2.10 (English and Arabic).

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Chang Feng-ch'i, 1959, Initial ideas on the karst leakage and dam site selection of the Hsiao Tui Ch'ung Reservoir: in Hydrogeology and engineering geology, 1959, no. 12: selected translations. Trans. from Shih Wen Ti Chih Kung Ch'eng Ti Chih (CPR), no. 12, pp. 10-37 and 39-41. JPRS 7853. OTS and SLA 61-23124. $11.50.

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of Greenland: Zeitschrift für Gletscherkunde und Glazialgeologie, v. 3, no. 2, pp. 253-255. AmMet Soc T-G-122; ord. LC or SLA. (4 pp.).

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Shekhter, F. N., 1958, Calculating the depth of frost-penetration in soil and the temperature of the frost-penetrated soil: Leningrad. glav. geofiz. observ., Trudy, no. 77, pp. 7-19. US Weather Bureau X-R-235. Loan LC or SLA.

Shuleikin, V. V., et al., Fluctuations in the heat balance of the Atlantic Ocean: Akad. nauk SSSR. Izvestiya, seriia geofiz., no. 6, pp. 729-740. AmMetSoc T-R-257. LC or SLA.

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Shumskii, P. A., 1955, Principles of structural glaciology: Izd. Akad. nauk SSSR., pp. 5-149, 239-248: Minerals of the ice group (13 pp.); Structure and goniometric symmetry of ordinary ice crystals (10 pp.); The basic physical properties of ordinary ice (24 pp.); Ice as a rock formation (15 pp.); Methods of petrographic ice study (56 pp.); AmMet Soc T-RC-8 (ord. LC or SLA).

Steinemann, S. von, 1958, Experimental investigations of the plasticity of ice: Beiträge zur Geologie der Schewiz, Hydrologie, no. 10, AmMetSoc M-GTC-1 (German). Ord. LC or SLA.

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Troll, Carl, 1944, Structural soils, solifluction, and frost climates of the earth: Geologische Rundschau, no. 34, pp. 545-694. SIPRE X-G-7. Loan LC or SLA.

Tsytovich, N. A. (ed.), 1958, Data on laboratory studies of frozen soils: Sb. no. 3, Moscow, Izd. Akad. nauk SSSR, 323 pp. AmMetSoc M-RTC-16. Ord. LC or SLA (2 pp. [review?]).

Tsytovich, N. A., and Sumgin, M. I., 1937, Principles of mechanics of frozen ground: transl. of Russ. monogr., Osnovaniia mekhaniki merzlykh gruntov. Moscow, Izd. Akad. nauk SSSR. SIPRE X-R-228. Loan LC or SLA.

Uspenskii, V. A., 1954, Geomagnetic problems and the internal structure of the earth: Akad. nauk SSSR, Geofiz. inst., Trudy, no. 26(153), pp. 208-210. DDC X-R-178. Loan LC or SLA.

Veinberg [Weinberg?], B. P., et al., 1940, Ice. Properties, origin, and disappearance of ice: Trans. of monogr. Led. Svoistva, vozniknovenie i ischeznovenie l'da. Moscow, Gosud. izd. tekh.-teoret.

lit., pp. 32-36, 67-72, 88-89, 392, 404 and 500-510. AmMetSoc T-R-101. Loan LC or SLA. (56 pp.).

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Yoshida, Zyungo, 1954, Quantitative study of the metamorphosis of snow crystals by sublimation: Teion Kagaku, ser. A., no. 13, pp. 11-38. SIPRE X-J-17. Loan LC or SLA (10 pp.).

Zubov, N. N., 1959, The maximum thickness of sea and land ice: Meteor. i gidr. no. 2, pp. 22-27. AmMetSoc T-R-201. Ord. LC or SLA (7 pp.).

REFERENCE SECTION

PREPUBLICATION ANNOUNCEMENTS FROM NOVYYE KNIGI (NEW BOOKS)

This section lists the announcements of forthcoming Russian geologic works translated from the weekly bibliographic bulletin Novyye Knigi (Ministerstvo Kul'tury SSSR, Vsesoyuznaya palata, Moscow). These lists are prepared as part of regular program of screening, acquisition, review, and translation. Because Soviet publishers print only enough copies for a closely predicted audience, Russian books are commonly out of print by the time many Western researchers get notice. These prepublication announcements should provide the advance notice needed for interested scientists and librarians to place orders in time to be reasonably assured of delivery. The names and addresses of several dealers specializing in Russian books follows this list.

This second list covers Novyye Knigi, 1961, numbers 5, 9, and 11 through 19, dated from January 31 through March 9 (numbers 6, 7, 8, and 10 were covered in IGR for November 1961). We hope soon to be able to publish these notices within a month or two of receipt of the bulletin.

1961, January 31 No. 5

Ali-Zade. Akchagyl Turkmenistana [THE AKCHAGYL OF TURKMENISTAN]. Gosgeoltekhizdat. 2,000 copies. R2.65.

This work describes the Akchagyl deposits of Turkmenia, including how variations in their thickness relate to oscillatory tectonic movements, and the nature of their contact with the underlying rocks. There is a separate chapter on the volcanic ashes of Turkmenistan. For geologists, stratigraphers and paleontologists. NK 1961-5, p. 39.

Voprosy Dinamicheskoy Teorii Rasprostraneniya Seysmicheskikh Voln [PROBLEMS OF THE DYNAMIC THEORY OF SEISMIC WAVE PROPOGATION]. Collection No. 4. Leningrad University Press. 5,000 copies. R1.46.

The first part of this collection deals with methods of the dynamic interpretation of the results of seismic observations, and also examines some problems of reverse kinematics. In the second part are investigations of methods of distinguishing field signals in a background of interference, and also new developments in apparatus. Results of an experiment in using the partial theory of grouping for the solution of production problems in complex seismogeologic conditions are discussed. For all seismologists and seismic prospectors. NK 1961-5, p. 39.

Kazarinov, V. P. and Gurova, T. I. Otsenka neftegazoperspektivnosti krupnykh vpadin Zapadnoy Sibiri po litologofatsial'nym dannym [EVALUATION OF THE OIL AND GAS-BEARING POTENTIAL OF LARGE DEPRESSIONS IN WESTERN SIBERIA FROM LITHOLOGIC FACIES DATA]. Gostoptekhizdat. 4,000 copies. R1. 55.

This work gives the results of a study of the sedimentary rocks of the Western Siberian Lowland, and includes data on the thickness of sediments, the composition and distribution of organic remains (micro- and macrofauna and flora), etc. The book is illustrated with colored paleogeographic maps, maps showing the distribution of fauna and flora, and numerous tables, diagrams, and figures. For geologists. NK 1961-5, p. 39.

Koreshkov, I. V. Oblasti svodnogo podnyatiya i osobennosti ikh razvitiya [REGIONS OF ARCHED UPLIFT AND FEATURES OF THEIR DEVELOPMENT]. Gosgeoltekhizdat. 3,000 copies. R1. 22.

This paper sets forth the concept of the geoanticlinal development of the earth's crust (in contradistinction to the geosynclinal). Geoanticlinal history is examined as a periodically increasing tectonic activity, beginning with orogeny, the creation of thick arches, and closing with volcanism of basaltic nature and the subsidence of the region. For geologists. NK 1961-5, p. 39.

Rasseyannoye organicheskoye veshchestvo i glinistyye mineraly terrigennykh mezozoyskikh i maykopskikh otlozheniy Vostochnogo Predkavkaz'ya [DIFFUSE ORGANIC MATTER AND CLAY MINERALS IN THE CONTINENTAL MESOZOIC AND MAIKOP DEPOSITS OF THE EASTERN PREDKAVKAZ'YE]. USSR Academy of Sciences Press. 2,000 copies. R1. 00.

New data is published on the mutual relationships of diffuse organic matter and clay minerals in the process of bitumen formation, and results of a combined investigation of diffuse organic matter and clay minerals of continental Mesozoic and Paleogene deposits of East Caucasus Foreland are given. The book is illustrated with figures and tables. For petroleum workers and lithologists. NK 1961-5, p. 40.

Stratigrafiya i litologiya permskikh i triasovykh otlozheniy severnoy chasti Priverkhoyanskogo progiba v svyazi s problemoy neftegazonosnosti [STRATIGRAPHY AND LITHOLOGY OF PERMIAN AND TRIASSIC DEPOSITS OF THE NORTH PART OF THE PRIVERKHOYANSK DOWNWARP IN CONNECTION WITH THE PROBLEM OF OIL AND GAS CONTENT]. Gostoptekhizdat. 3,000 copies. R1. 20.

The results of stratigraphic, lithologic and geochemical investigations of Permian and Triassic deposits in the Ust'-Lena region are given, as well as results of an investigation of the methods used. A number of stratigraphic boundaries were made more precise, and faunal horizons were set up which may serve as marker horizons during geologic surveys. For petroleum geologists. NK 1961-5, p. 40.

Trebovaniya promyshlennosti k kachestvu mineral'nogo syr'ya. Vyp. 7. Kvarts, peschanik, zhil'nyy kvarts [QUALITATIVE INDUSTRIAL REQUIREMENTS FOR MINERAL RAW MATERIALS, NO. 7, QUARTZ- SANDSTONE, VEIN QUARTZ]. Gosgeoltekhizdat. 10,000 copies. R0. 14.

The properties of mineral raw materials, regions of application, types of deposit, methods of initial processing, technical requirements for the raw material (standards, departmental technical conditions, etc.), field methods of study of samples and specimens, are examined. For geologists. NK 1961-5, p. 40.

NOTE: Title and transliteration for the following five items are identical with the title of the item

next above, with the exception of the Vypusk [number] and the name of the material. The descriptive paragraph is the same for all six materials.

Vyp. 10. Izvestnyak [NO. 10. LIMESTONE] R0. 21
Vyp. 20. Dolomit [NO. 20. DOLOMITE] R0. 18
Vyp. 28. Vismut [NO. 28. BISMUTH] R0. 14
Vyp. 39. Olovo [NO. 39. TIN] R0. 21
Vyp. 40. Magnezit [NO. 40. MAGNESITE] R0. 14

Tugarinov, A. I. Geologu o metodakh opredeleniya absolyutnogo vozrasta gornykh porod [METHODS OF DETERMINING THE ABSOLUTE AGE OF ROCKS FOR THE GEOLOGIST]. Gosgeoltekhizdat. 3,000 copies. R0. 03.

The following methods of determining the absolute age of rocks are discussed: lead-uranium-thorium, argon-potassium, calcium-potassium, strontium-rubidium. Some information is given for the radiocarbon, ionic, and tritium methods. For geologists. NK 1961-5, p. 40.

Ustiyev, Ye. N. Anyuyskiy vulkan i problemy chetvertichnogo vulkanizma Severo-Vostoka SSSR [ANYUYSK VOLCANO AND PROBLEMS OF QUATERNARY VOLCANISM IN THE NORTHEAST USSR]. Gosgeoltekhizdat. 15,000 copies. R0. 87.

This work is about the geology and petrography of the area around the Monni River. A number of general petrographic problems of great theoretical significance are discussed; the age of the eruptions and their sequence, depth of the peripheral focus, etc., are discussed. For geologists. NK 1961-5, p. 41.

Yun'kov, A. A., Afanas'yev, N. L., and Fedorova, N. A. Interpretatsiya anomality pod kontaktami i sbrosami. Chast' I [THE INTERPRETATION OF ANOMALIES UNDER CONTACTS AND FAULTS. PART I.]. Gosgeoltekhizdat. 2,500 copies. R0. 21.

This book presents a series of diagrams which have been designed for the interpretation of anomalies under contacts and faults, which have been treated as inclined or vertical steps. For engineers and geophysicists investigating gravity anomalies. NK 1961-5, p. 41.

Ibid. Chast' II [Part II.] Gosgeoltekhizdat. 2,500 copies. R0. 09.

A series of diagrams which have been designed for the interpretation of V_Δ, Vzz, and Z anomalies under various steps, both finite and infinite, along and across the strike. For geophysicists investigating gravity and magnetic anomalies. NK 1961-5, p. 41.

Ibid. Chast' III [Part III.] Gosgeoltekhizdat. 2,500 copies. R0. 11.

A series of diagrams which have been designed for the interpretation of Vxz and H anomalies under various vertically magnetized inclined steps, both finite and infinite, along and across the strike. Diagrams are compiled only for the Vxz anomaly. For geophysicists investigating gravity and magnetic anomalies. NK 1961-5, p. 41.

Trudy IV sessii Vsesoyuznogo paleontologicheskogo obshchestva [TRANSACTIONS, 4TH SESSION OF THE ALL-UNION PALEONTOLOGICAL SOCIETY]. Gosgeoltekhizdat. 2,000 copies. R1. 36.

A considerable part of the papers is devoted to relating the successes of paleontology in the USSR during the 40 years of Soviet power. In addition, some reports examine general problems of evolution theory, regional problems of biostratigraphy, etc. For paleontologists and geologists. NK 1961-5, p. 41.

Ivanov, S. K. and Mikhaylovskiy, V. N. Novyye pribory dlya izmereniya krivizny razvedochnykh skvazhin [NEW APPARATUS FOR THE MEASUREMENT OF THE CURVATURE OF EXPLORATORY DRILL HOLES]. Gosgeoltekhizdat. 3,000 copies. R0. 80.

In this brochure, methods of measurement, the processing of results, and the plotting of exploratory drill hole paths are set forth; simpler and more precise formulae than have heretofore been recommended are examined; actual and hypothetical results of the instruments' use are shown; and instructions for the operation of the instruments are given. For geological reconnaissance workers. NK 1961-5, p. 47.

Issledovaniya po obogashcheniyu i tekhnologii poleznykh iskopayemykh [INVESTIGATIONS ON THE ENRICHMENT AND TECHNOLOGY OF ORE MINERALS] Edited by I. V. Shmanenkov. Gosgeoltekhizdat. 2,000 copies. R1. 43.

Methods of study of the material composition of ores of certain ferrous, nonferrous, rare and native metals; problems of methods of the technological study of lignite and coking coal during the survey of new coal deposits; and similar problems are treated. For geologists, technologists, and personnel of beneficiation plants. NK 1961-5, p. 47.

1961, February 28 — No. 9

Zavaritskiy, A. N. Izverzhennyye gornyye porody. Izd. 3-ye [IGNEOUS ROCKS, 3rd edition]. USSR Academy of Sciences Press. 15,000 copies. R3. 00.

This book summarizes the very rich fund of knowledge about igneous rocks derived from their study in the USSR and foreign countries. More than 200 figures, showing the rock types which are described, are included. For geologists and petographers. NK 1961-9, p. 31.

Kogan, B. I. Ekonomicheskiye ocherki po redkim zemlyam [ECONOMIC PAPERS ON THE RARE EARTHS]. USSR Academy of Sciences Press. 4,000 copies. R1. 30.

The author analyzes the present-day significance of the rare earths, their properties, the development of methods of obtaining them in the pure state, and prospecting for their raw materials. He examines the applications of them and conditions in the industry of rare earths abroad, and prospects for their utilization in new regions. A detailed bibliography on rare earths is included. For geologists, geophysicists, geochemists, chemists and economists. NK 1961-9, p. 31.

Mikhaylov, V. I. Gory Yuzhnoy Sibiri [MOUNTAINS OF SOUTHERN SIBERIA] Geografgiz. 10,000 copies. R0. 60.

This book contains the comprehensive generalized characteristics of the mountains of Southern Siberia and, in a special section, a detailed description of its regions. Special attention is given to the practical evaluation of natural resources. The publication

is well illustrated, and is supplied with numerous original maps and sketches. For geographers, workers in planning organizations, industry, transportation, and agriculture. NK 1961-9, p. 31.

Trebovaniya promyshlennosti k kachestvu mineral'nogo syr'ya. Vyp. 49. Magnezit [INDUSTRIAL REQUIREMENTS FOR THE QUALITY OF MINERAL RAW MATERIALS. NO. 49. MAGNESITE]. Gosgeoltekhizdat. 10,000 copies. R0.18.

The properties of magnesite, fields of its use, types of deposits, methods of initial processing, technical requirements for it (standards, technical conditions in departments, etc.) field methods of study of samples and specimens. NK 1961-9, p. 31.

Trebovaniya promyshlennosti k kachestvu mineral'nogo syr'ya. Vyp. 69. Bor [INDUSTRIAL REQUIREMENTS FOR THE QUALITY OF MINERAL RAW MATERIALS. NO. 69. BORON]. Gosgeoltekhizdat. 10,000 copies. R0.19.

[No descriptive passage given--presumably the same as for Magnesite, above.]

1961, March 14 — No. 11

Shevchenko, A. I. Gidrogeologicheskaya klassifikatsiya oroshayemykh territoriy Uzbekistana [HYDROGEOLOGICAL CLASSIFICATION OF THE IRRIGATED LANDS OF UZBEKISTAN]. Uzbek SSR Academy of Sciences Press. 1,500 copies. R1.12.

This monograph introduces a hydrogeological classification of irrigated lands as a scientific basis for their subdivision. The subdivision according to the principles proposed by the author is described using the plains of central and western Uzbekistan currently being irrigated or to be irrigated in the near future as examples. For hydrogeologists and reclamation engineers. NK 1961-11, p. 43.

Piotrovskiy, V. V. Geomorfologiya s osnovami geologii [GEOMORPHOLOGY WITH THE PRINCIPLES OF GEOLOGY]. Geodezizdat. 4,000 copies. R0.83.

The basic concepts of dynamic and historical geology and geomorphology, material on the decipherment of relief forms on aerial photographs and the depiction of these forms on topographic maps are given in this book. For students of cartography, departments of geodetic institutes. NK 1961-11, p. 52.

1961, March 21 — No. 12

Metody khimicheskogo analiza mineralov. (Trudy In-ta geologii rudnykh mestorozhdeniy, petrografii, mineralogii i geokhimii Akad. nauk SSSR. Vyp. 64) [METHODS FOR THE CHEMICAL ANALYSIS OF MINERALS. (TRANSACTIONS, INSTITUTE OF THE GEOLOGY OF ORE DEPOSITS, PETROGRAPHY, MINERALOGY, AND GEOCHEMISTRY OF THE ACADEMY OF SCIENCES OF THE USSR. NO. 64)]. USSR Academy of Sciences Press. 2,500 copies. R0.60.

The articles deal with methods for the chemical analysis of certain ores and minerals, the analysis of molybdenum-tungsten minerals, tetrahedrite and sulfide minerals, pyrochlore and spinels. The identification of rare earths in zircons and the qualitative determination of boron in the field are given, and the application of ion-exchange resins in the analysis of apatites and other minerals is examined. For analytical chemists and scientific workers. NK 1961-12, p. 25.

Seysmichnost' Uzbekistana. Vyp. I [SEISMICITY OF UZBEKISTAN. NO. 1]. Uzbek SSR Academy of Sciences Press. 1,500 copies. R1.04.

This work presents a summary of all the macroseismic data, beginning with 1883, including instrumental data from 1911 on, and also data from the expeditionary network which operated in the Tashkent region, in the Naryn River basin, and in the Fergana Valley in 1956-1958. Maps have been compiled showing: epicenters of strong and perceptible earthquakes in the Fergana Valley; epicenters in the Fergana Valley according to instrumental data; the density of epicenters in groups in the Fergana Valley according to instrumental data; and seismic activity. For geologists, seismologists, and scientific and technical engineering workers. NK 1961-12, p. 26.

Pankov, M. A. Protsessy zasoleniya i rassoleniya pochv Golodnoy stepi [PROCESSES OF SALINIZATION AND DESALINIZATION OF SOILS OF THE GOLODNAYA STEPPE]. Uzbek Academy of Agricultural Sciences Press. 1,500 copies. R2.30.

In this book, the genesis and present-day processes of salinization and desalinization of soils and ground water of the Golodnaya Steppe are discussed. The soils of the Golodnaya Steppe are described, their geographic distribution is given, and the origin of the salinization is established. Problems of the secondary salinization of soils under the influence of irrigation, by stages of land development for cultivation, and the present-day situation regarding salinization of soils and ground water, the water-salt regime and balance of soils, are examined. A soils-reclamation classification of the Golodnaya Steppe is given, along with recommendations for the prevention of and fight against salinization in lands being brought under cultivation and already under cultivation. For soil scientist specialists. NK 1961-12, p. 36.

Slyadnev, A. F. Metody izucheniya balansa gruntovykh vod [METHODS OF STUDY OF THE BALANCE OF GROUND WATER]. Uzbek SSR Academy of Sciences Press. 1,500 copies. R1.46.

In this work, methods of study of the balance of ground water in cotton fields, and the dynamics of moisture reserves in the zone of aeration are published, using the Golodnaya Steppe as an example. Equations for the ground-water balance of cotton fields are given. The monograph describes measuring apparatus and methods of using apparatus for the quantitative determination of moisture dynamics in the zone of aeration, and elements of the water balance, salt regime, and heat dynamics in soils. For hydrogeologists and reclamation engineers. NK 1961-12, p. 36.

1961, March 28 — No. 13

Kireyev, P. S. Molekulyarnyy spektral'nyy analiz [MOLECULAR SPECTRAL ANALYSIS]. "Vysshaya Shkola" Press. 10,000 copies. R0.18.

In this brochure are treated the problems, capabilities, features, methods, and means for the practical application of molecular spectral analysis. The theoretical basis of molecular spectra is given,

particularly of emission, absorption, and combination spectra. Infrared spectroscopy and luminescence analysis are taken up. Short descriptions of apparatus used for molecular spectroscopic analysis are given. NK 1961-13, p. 31.

Metodicheskoye rukovodstvo po opredeleniyu mikrokomponentov v prirodnykh vodakh pri poiskakh rudnykh mestorozhdeniy [HANDBOOK FOR METHODS OF DETERMINING MICROCOMPONENTS OF NATURAL WATERS IN PROSPECTING FOR ORE DEPOSITS]. Edited by I. Yu. Sokolov. Gosgeoltekhizdat. 10,000 copies. Rl. 65.

This book describes the chemical, polarographic, and spectrographic methods of determining microquantities of a large number of elements in natural waters: boron, bromine, iodine, vanadium, germanium, cobalt, copper, molybdenum, arsenic, and others. A general evaluation of the methods of concentrating and determining the microcomponents is given, and the methods of determining the oxidation-reduction potential of water and certain components having great importance in the establishment of the oxidation-reduction potential (oxygen, hydrogen sulfide) are described. For analysts doing analyses of water and also for geologists and hydrogeologists. NK 1961-13, p. 33.

Voprosy gidrogeologii i inzhenernoy geologii. (Sbornik trudov Vsesoyuz. nauch.-issled. in-ta gidrogeologii i inzhenernoy geologii No. 19) [PROBLEMS OF HYDROGEOLOGY AND ENGINEERING GEOLOGY. (A COLLECTION OF PAPERS OF THE ALL-UNION SCIENTIFIC RESEARCH INSTITUTE OF HYDROGEOLOGY AND ENGINEERING GEOLOGY, NO. 19)]. Gosgeoltekhizdat. 1,500 copies. R1. 24.

In this collection are published the results of several scientific research projects, carried out by workers of the institute in recent years, in the fields of hydrogeology and engineering geology. In hydrogeology the following problems are discussed: the classification of springs; atmospheric salinization of ground water on the northern fringes of deserts using the Turgay downwarp as an example; the study of organic substances in ground water in Dagestan ASSR; hydrogeologic conditions and the ground water regime in the Golodnaya Steppe and others. In engineering geology: engineering geology characteristics of Quaternary deposits of the central part of the Amu-Dar'ya valley; swelling of clayey rocks in relation to their origin, using the Moscow lignite basin as an example; engineering geology classification of the eastern Sayan, etc. For technical-engineering and scientific workers. NK 1961-13, p. 34.

Vostokova, Ye. A. Geobotanicheskiye metody poiskov podzemnykh vod v zasushlivykh oblastyakh SSSR [GEOBOTANICAL METHODS OF PROSPECTING FOR GROUND WATER IN ARID REGIONS OF THE USSR]. Gosgeoltekhizdat. 1,500 copies. R0. 62.

This work deals with problems of the utilization of the vegetative cover as an index to the depth of occurrence and degree of mineralization of ground water in arid regions. Plants and plant associations are described, and individual pictures of plants which serve as indicators of hydrogeologic conditions in the arid zone are given. Methods of using geobotanical indicators are worked out for hydrogeologists, reclamation engineers and other specialists in the practice of their professions. NK 1961-13, p. 34.

Geologicheskiy sbornik. Vyp. 6 [GEOLOGICAL COLLECTION OF PAPERS, NO. 6]. Gostoptekhizdat. 2,000 copies. R1. 90.

This collection is for geologists and engineering technicians in industry, exploration work and in scientific research organizations. The distribution of oil and gas deposits, as well as the oil and gas potential of the western Fore-Caucasus (Predkavkaz'ye), is considered in the light of present-day concepts of its geologic structure. Results of investigations of Cretaceous and Miocene rocks of some regions of Krasnodar Kray are given. Reservoir rocks of the Lower Cretaceous of the gas-bearing deposits of Kuban' and the Miocene of the western Kuban' downwarp are described. NK 1961-13, p. 34.

Zavaritskiy, A. N. and Sobolev, V. S. Fiziko-khimicheskiye osnovy petrografii izverzhennykh gornykh porod [THE PHYSICO-CHEMICAL BASES OF THE PETROGRAPHY OF IGNEOUS ROCKS]. Gosgeoltekhizdat. 3,000 copies. R2. 60.

General concepts of thermodynamics and physical chemistry are examined; data from experimental investigations of one, two, three and from some four component systems without volatile components are given, along with an examination of the meaning of these data in the explanation of magma crystallization; the results of experimental investigations of silicate systems containing volatile components, especially water, are presented. For geologists, petrographers, survey and scientific workers studying igneous and metamorphic rocks. NK 1961-13, p. 34.

Sosedko, A. F. Materialy po mineralogii i geokhimii granitnykh pegmatitov [DATA ON THE MINERALOGY AND GEOCHEMISTRY OF GRANITE PEGMATITES]. Gosgeoltekhizdat. 1,500 copies. R1. 01.

A great amount of factual material on the mineralogy and geochemistry of the granite pegmatites of the Kola Peninsula is collected in this work. Detailed descriptions of the chief minerals of the granite pegmatite veins are given, as well as the structure of the basic types of veins within the framework of a short geologic and petrographic description of the region. A number of conclusions are made regarding the causes for the distribution of pegmatite veins of various compositions in one pegmatite field, and regarding the occurrence of rare elements in different veins and minerals. For petrographers, survey-geologists, geochemists, and mineralogists. NK 1961-13, p. 34.

Trebovaniya promyshlennosti k kachestvu mineral'nogo syr'ya. Vyp. 48. Prirodnoye krasochnoye syr'ye [INDUSTRIAL REQUIREMENTS FOR THE QUALITY OF MINERAL RAW MATERIALS. NO. 48. NATURAL DYESTUFFS]. Gosgeoltekhizdat. 10,000 copies. R0. 14.

The properties of natural dyestuffs, fields of their use, types of deposits, methods of their initial processing, technical requirements for them (standards, departmental technical conditions, etc.) are considered in this publication. Economic data on the development and present-day situation of this field of the mining industry are given. For geologists. NK 1961-13, p. 35.

Shcherbakov, A. V. Gidrogeologicheskiye issledovaniya pri poiskakh i razvedke podzemnykh borono-

snykh vod [HYDROGEOLOGIC INVESTIGATIONS DURING THE EXPLORATION FOR AND SURVEY OF UNDERGROUND WATERS CONTAINING BORON]. Gosgeoltekhizdat. 2,000 copies. R0.66.

This work, on the basis of the summarization and scientific analysis of available material, presents information on the geochemistry of boron, principal types of boron-containing ground water and features of its occurrence, in conformity with structural geology-, lithologic-stratigraphic-, hydrodynamic-, and hydrogeochemical features. Methods of conducting hydrogeologic investigations of these waters are given. For geologists. NK 1961-13, p. 35.

Il'gel', L. Ye. Ekzogennyye mestorozhdeniya selena (Geologiya mestorozhdeniy redkikh elementov. Vyp. 11). [EXOGENOUS DEPOSITS OF SELENIUM. (GEOLOGY OF DEPOSITS OF RARE ELEMENTS, NO. 11)]. Gosgeoltekhizdat. 7,000 copies. R0.92.

The author gives some information on the significance of selenium in industry, sources from which it is obtained, data on the extraction and trading of selenium in capitalist nations, basic information on its physico-chemical properties, main features of its geochemistry, and gives descriptions of selenium minerals and diagnostic features of its hypergene minerals. A classification of isogenous selenium deposits is proposed for the first time. For geologists. NK 1961-13, p. 35.

Vilenskiy, D. G. Geografiya pochv. Ucheb. posobiye dlya un-tov, ped., s-kh. i lesokhoz. in-tov. [THE GEOGRAPHY OF SOILS. TEXTBOOK FOR UNIVERSITIES, PEDOLOGICAL, AGRICULTURAL, AND FORESTRY INSTITUTES]. "Vysshaya Shkola" Press. 5,000 copies. R0.70.

The textbook consists of three parts. In the first general part, the contents and problems of the science of the geography of soils and the significance of the geographic distribution of soils for diversified agriculture and other branches of the economy of the USSR are examined. The characteristics of the natural factors influencing the soil-forming processes and the world geography of soils are given. In the second part, the soils of the USSR are examined in detail. In the third part, soils of the "People's Democracies" are described. NK 1961-13, p. 51.

Nikolayev, V. A., and Dolivo-Dobrovol'skiy, V. V. Osnovy teorii protsessov magmatizma i metamorfizma [FUNDAMENTALS OF THE THEORY OF MAGMATIC AND METAMORPHIC PROCESSES]. Gosgeoltekhizdat. 3,000 copies. R2.10.

A fundamental work, taking up in much detail the basic concepts of the theory of equilibrium and laws of phase relationships which characterize the crystallization of rock-forming silicates, and also the most typical phase reactions of metamorphism. Problems and examples of calculations, tables, and instructions are appended. For geology students. NK 1961-13, p. 53.

Flint, Ye. Ye. Nachala kristallografii. Uchebnik dlya studentov geologicheskikh vuzov i fakul'tetov. Izd. 3-ye. [BEGINNING CRYSTALLOGRAPHY. TEXTBOOK FOR STUDENTS OF GEOLOGICAL INSTITUTES AND DEPARTMENTS. 3rd edition]. "Vysshaya Shkola" Press. 5,000 copies. R0.50.

(No descriptive passage.) NK 1961-13, p. 54.

1961, April 4	No. 14

Atlas ugley Kavkaza [ATLAS OF CAUCASIAN COALS] USSR Academy of Sciences Press. 2,000 copies. R2.50.

This book contains a description of all Carboniferous, Jurassic, and Tertiary coal and gagate (jet) deposits of the Caucasus. For each deposit is given the geology of the region, a description of the component parts (microcomponents) of the coals, a classification of the types of coals, coal beds, jets, and their chemical-technological features. The publication is illustrated with 235 colored and black-and-white photos of coal and gagitic structures and with 28 maps and sections. A short survey of coal occurrences in the Caucasus is given. The title page, annotations, table of contents, and list of photographs are also given in English. For geologists. NK 1961-14, p. 38.

Pervichnaya produktsiya morey i vnutrennikh vod SSSR. (Trudy soveshchaniya po pervichnoy produktsii vodoyemov) [PRODUCTS FROM PRIMITIVE ORGANISMS IN THE SEAS AND INTERNAL WATERS OF THE USSR. (TRANSACTIONS, CONFERENCE ON PRODUCTS FROM PRIMITIVE ORGANISMS IN RESERVOIRS)]. Belorussian University Press. 3,000 copies. R1.50.

The newest methods of study of products from primitive organisms with the aid of radioactive isotopes of carbon, on the content of chlorophyll in plankton, etc., are examined in this work. Methods of study of the light regime of reservoirs, the microbiologic processes in reservoirs, problems of the utilization of the products of primitive organisms and making it economically valuable, means of artificially increasing the productivity of reservoirs are treated also. For biologists, oceanologists, limnologists, plant physiologists, geographers, hydrochemists. NK 1961-14, p. 38.

1961, April 11	No. 15

Gordeyev, D. I. M. V. Lomovosov--Osnovopolozhnik geologicheskoy nauki. (K 250-letiyu so dnya rozhdeniya M. V. Lomonosova. 1711-1961) [M. V. LOMONOSOV - A FOUNDER OF THE SCIENCE OF GEOLOGY. (IN COMMEMORATION OF THE 250th ANNIVERSARY OF HIS BIRTH, 1711-1961)]. Moscow University Press. 5,000 copies. R0.60.

This work sets forth the teachings of M. V. Lomonosov on the structure and history of the earth, his role in the development of the different branches of geology, and his struggle for the study of the mineral wealth of Russia. Much material is introduced on the subsequent adherence to the Lomonosov school in Russian geology during the two centuries after the death of Lomonosov. A bibliography is included. NK 1961-15, p. 35.

Dik, N. Ye. M. V. Lomonosov i geografiya. (K 250-letiyu so dnya rozhdeniya M. V. Lomonosova. 1711-1961.) [M. V. LOMONOSOV AND GEOGRAPHY. (IN COMMEMORATION OF THE 250th ANNIVERSARY OF HIS BIRTH. 1711-1961)]. Moscow University Press. 5,000 copies. R0.60.

This book is based both on sources in the literature and on the author's own research. It encompasses quite completely the activities of M. V. Lomonosov in the field of geography. Works of the great scientist on physical and economic geography,

cartography, and on the study of northern regions are treated. NK 1961-15, p. 35.

Makhnach, A. S., Golybtsov, V. K., and others. Fatsii territorii Belorussii v paleozoye i rannem mezozoye [THE FACIES OF BELORUSSIA IN THE PALEOZOIC AND EARLY MESOZOIC]. Belorussian SSR Academy of Sciences Press. 1,500 copies. R0. 90.

The facies of Belorussia and adjacent regions are examined in this book. The facies analyses are carried out by stratigraphic units. The work contains more than 40 maps, compiled by the authors and published for the first time, on which are depicted the paleographic features of Belorussia for various periods of time. For all kinds of geologists. NK 1961-15, p. 35.

Mashanov, A. Zh. Mekhanika massiva gornykh porod [MECHANICS OF ROCK MASSES]. Kazakh SSR Academy of Sciences Press. 3,000 copies. R0. 75.

This monograph summarizes 20 years' work in research on the influence of mass structures in solving various mining problems. The author has worked out a new theory for the density of rock masses. A short description of the mechanism of formation of the chief types of mass structures is given, as well as methods of their study. Numerous examples of the application of the new theory and methods of study of mass structures from the mines of Kazakhstan. For mining engineers and geologists. NK 1961-15, p. 35.

Pidoplichko, A. P. Genezis, stratigrafiya i rayonirovaniye torfyanykh mestorozhdeniy Belorussoy SSR [GENESIS, STRATIGRAPHY, AND LAND CLASSIFICATION OF PEAT DEPOSITS IN THE BELORUSSIAN SSR.] Belorussian SSR Academy of Sciences Press. 1,500 copies. R1. 00.

This monograph deals with problems of the formation, structure, and land classification of peat deposits in the Belorussian SSR. For scientists, engineers and peat industry technicians. NK 1961-15, p. 35.

Trudy litologicheskoy konferentsii [TRANSACTIONS, LITHOLOGIC CONFERENCE.] Belorussian SSR Academy of Sciences Press. 1,500 copies. R1. 55

The papers deal with the study of Quaternary deposits. For geologists. NK 1961-15, p. 36.

Kholak, Yu. A. Petrografo-mineralogicheskaya kharakteristika nizhnekembriyskikh otlozheniy Aldanskogo rayona Yakutskoy ASSR [PETROGRAPHIC AND MINERALOGIC CHARACTERISTICS OF LOWER CAMBRIAN DEPOSITS OF THE ALDAN REGION OF THE YAKUTSK ASSR.] USSR Academy of Sciences Press. 2,000 copies. R0. 60.

This work gives a detailed petrographic and mineralogic description of the Lower Cambrian rocks of the Aldan Region of the Yakutsk ASSR; it describes the microscopic, chemical, and thermal characteristics of the rocks, and also gives information on bitumen content and occurrence. For geologists, petrographers, and mineralogists. NK 1961-15, p. 36.

1961, April 18 — No. 16

Kiselev, P. A. Issledovaniye balansa gruntovykh vod po kolebaniyam ikh urovnya. [INVESTIGATION OF GROUND WATER BALANCE USING VARIATIONS IN THEIR LEVELS.] Belorussian SSR Academy of Sciences Press. 2,000 copies. R0. 75.

This monograph deals with the theory and methods of study of the ground-water balance using observational data of variations in ground-water levels. Methods of predicting variations in ground-water level are given. For scientific technicians, engineering geologists, hydrogeologists, hydrotechnical workers, builders. NK 1961-16, p. 39.

Sidorenko, A. V. and Luneva, O. I. K voprosu o litologicheskom izuchenii metamorficheskikh tolshch [LITHOLOGIC STUDY OF METAMORPHIC ROCKS.] USSR Academy of Sciences Press. 2,000 copies. R0. 96

The book announces the finding of original sedimentary rock features in the metamorphic rocks of the Kola Peninsula. The study of structural and textural features makes possible the decipherment of the premetamorphic stage of ancient sediments formation and the reconstruction of the paleogeography of certain parts of the Precambrian. The value of special lithologic studies of metamorphic rocks is substantiated. For geologists. NK 1961-16, p. 39.

Trebovaniya promyshlennosti k kachestvu mineral'nogo syr'ya. Vyp. 66. Ugol' [INDUSTRIAL REQUIREMENTS FOR THE QUALITY OF MINERAL RAW MATERIALS. NO. 66. COAL.] Gosgeoltekhizdat. 10,000 copies. R0. 21.

The properties of coal, fields of its application, types of its deposits, methods of initial processing, technical requirements for it (standards, departmental technical conditions, etc.), and field methods of study of samples and specimens are examined. Data is given on the history and current situation of this branch of the mining industry. For geologists. NK 1961-16, p. 39.

Sbornik nauchnykh rabot Belorusskogo otdeleniya Vsesoyuznogo botanicheskogo obshchestva. Vyp. 3 [COLLECTION OF SCIENTIFIC WORKS OF THE BELORUSSIAN SECTION OF THE ALL-UNION BOTANICAL SOCIETY. NO. 3.] Belorussian SSR Academy of Sciences Press. 1,500 copies. R1. 20.

Existing problems of plant physiology and anatomy, dendrology, genetics, geobotany, introduction, paleobotany, morphology and plant systematics are treated. For botanists, foresters and agricultural specialists. NK 1961-16, P. 39.

1961, April 25 — No. 17

Viktorov, S. V. and Vostokova, Ye. A. Osnovy indikatsionnoy geobotaniki [FUNDAMENTALS OF DETERMINATIVE GEOBOTANY.] Gosgeoltakhizdat. 1,500 copies. R0. 52.

The theory and practice of geobotany in prospecting for useful minerals, in engineering geology mapping and hydrogeological mapping, etc., are discussed. Methods of compiling special geobotanical determinative maps, the organization of geobotanical investigations in geological organizations, etc., are examined. For geologists, hydrogeologists, specialists in engineering geology, and soil scientists. NK 1961-17, p. 31.

Voprosy geografii Kazakhstana. Sbornik statey. Vyp. 8 [PROBLEMS OF KAZAKHSTAN GEOGRAPHY.

COLLECTION OF ARTICLES No. 8.] Kazakh SSR Academy of Sciences Press. 1,500 copies. R1. 20.

In this collection problems of glaciology, hydrology, and climate are discussed for various regions of the Republic. The articles are compiled from data from the most recent investigations. For scientific workers. NK 1961-17, p. 31.

Voprosy dinamicheskoy teorii rasprostraneniya seysmicheskikh voln. Sb. 5 [PROBLEMS OF THE DYNAMIC THEORY OF SEISMIC WAVE PROPAGATION. COLLECTION NO. 5.] Leningrad University Press. 5,000 copies. R1. 32.

This collection deals with mathematical investigations of the dynamic theory of seismic wave propagation. Chief attention is given to the radial method. The problem of distinguishing nonregular parts of the wave field, to which are related the chief processes of propagation of nonstationary signals, is widely discussed. In a number of articles the study of the fundamental laws governing the propagation of waves in media containing thin flat parallel layers is treated. Problems touching on the selection of equations of motion in an absorbing medium, similar to actual seismic media, are considered. For scientists, seismologists and seismic exploration workers. NK 1961-17, p. 31.

Geologiya i neftegazonosnost' zapada Sredney Azii. (Trudy Vsesoyuz. nauch. issled. geol. in-ta. Vyp. 2) [GEOLOGY AND OIL AND GAS POTENTIAL IN WESTERN CENTRAL ASIA. TRANSACTION, ALL-UNION SCIENTIFIC RESEARCH GEOLOGICAL INSTITUTE, NO. 2.] 3,000 copies. R2. 10.

This book is for geologists, geophysicists, and hydrogeologists. In it the results of research on the oil and gas potential of the western part of Central Asia are published. The structure and structural features of the Paleozoic basement; the tectonics of the sedimentary mantle of the Karakum; the stratigraphy, lithology, and facies of sedimentary rocks of the Mesozoic and Cenozoic, and problems of lithologic facies analysis, etc. are taken up. NK 1961-17, p. 31.

Glyatsiologicheskiye issledovaniya v period MGG (Zailiyskiy i Dzhungarskiy Alatau) [GLACIOLOGICAL INVESTIGATIONS IN THE IGY (TRANS-ILI AND DZHUNGARIAN ALATAU.)] Kazakh SSR Academy of Sciences Press. 1,500 copies. R1. 15.

This collection of papers is compiled from data of glaciological research carried out as part of the program of the International Geophysical Year. It contains articles on the meteorological regime of the glacier zone, on geophysical methods in glaciology which were used during the IGY on the glaciers of Kazakhstan, on the temperature and hydrologic regime of glaciers, on the dynamics and extent of glaciation, on the physical properties of the ice of glaciers, on snow cover in the glacier zone, and on other topics. For scientific workers, teachers, and many kinds of readers. NK 1961-17, p. 31.

Trebovaniya promyshlennosti k kachestvu mineral'nogo syr'ya. Vyp. 72. Toriy [INDUSTRIAL REQUIREMENTS FOR THE QUALITY OF MINERAL RAW MATERIALS. NO. 72. THORIUM.] Gosgeoltekhizdat. 10,000 copies. R0. 35.

The properties of thorium, fields of its application, types of its deposits, methods of initial processing, technical requirements for it, field methods of study samples and specimens, are examined. Economic data on the history and current status of this field of the mining industry are given. For geologists. NK 1961-17, p. 32.

Bazhanov, V. S. and Kostenko, N. N. Atlas rukovodyashchikh form mlekopitayushchikh antropogena Kazakhstana [ATLAS OF PREDOMINANT MAMMALIAN FORMS IN THE ANTHROPOGENE OF KAZAKHSTAN.] Kazakh Academy of Sciences Press. 1,500 copies. R0. 35.

The characteristics of the mammalian fauna of various epochs of the Anthropogene (which is being considered in an expanded sense—to include the second half of the Pliocene) are given within the framework of the geologic processes taking place in the country, and lanscapes existing at that time. The text is illustrated with maps showing finds of fossil material, type sections, and pictures of bone remains most useful for systematic identification, and also restorations of the external appearances of the chief faunal representatives. For paleotologists, geologists, and regional experts. NK 1961-17, p. 32.

Ivshin, I. K. Verkhnekembriyskiye trilobity Kazakhstana. Chast' II. Seletinskiy faunisticheskiy gorizont [UPPER CAMBRIAN TRILOBITES OF KAZAKHSTAN. PART 2. THE SELETINSKIY FAUNAL HORIZON.] Kazakh SSR Academy of Sciences Press. 1,500 copies. R0. 80.

This monograph contains descriptions of 75 species of trilobites from the Seletinskiy horizon of the Kuyankinsk stage. Diagnostic features of 25 new species are introduced. Correlation of the biostratigraphic scale of the Upper Cambrian of Kazakhstan, Western Siberia, the Siberian platform, China, Western Europe, and North America is made. For paleontologists and stratigraphic geologists. NK 1961-17, p. 32.

Osnovy Paleontologii. Spravochnik dlya paleontologov i geologov. Tom. Mlekopitayushchiye [PRINCIPLES OF PALEONTOLOGY. HANDBOOK FOR PALEONTOLOGISTS AND GEOLOGISTS. VOLUME — MAMMALS.] Gosgeoltekhizdat. 10,000 copies. R3. 70.

Descriptions of 6 subclasses and 27 orders of mammals are given, as well as a survey of the replacement of fossil fauna, a survey of morphology, etc.; and the stratigraphic basis for the continental deposits of the Cenozoic using remains of fossil fauna is given. NK 1961-17, p. 32.

1961, May 4 and 9 — Nos. 18 and 19

No geologic works listed.

DEALERS OF SOVIET PUBLICATIONS IN THE U. S.

Presumably any book dealer in the U. S. could take orders for and supply Soviet books. The dealers listed here either specialize or have long experience in the field. Listing is alphabetical.

Four Continent Book Corporation
822 Broadway
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Imported Publications and Products
4 West Sixteenth Street
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Moore-Cattrell Subscription Agencies, Inc.
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31 East Tenth Street
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Telberg Book Co.
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Universal Distributors
52-54 West Thirteenth Street
New York 11, New York

Victor Kamkin, Inc.
2906 Fourteenth Street, N. W.
Washington, 9, D. C.

AUTHOR INDEX

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The author spellings here may, in isolated instances, vary from those of the original article. Where such variations are likely to cause confusion, cross references are given. Names of Japanese and Chinese authors are listed surname first, given name second, without a comma between after oriental custom; to avoid confusion, the family name is given in capitals. Where an author's contriubion to a serial work is limited to one installment of the series, page numbers for all parts are given, and the page or pages containing the author's contributions is underlined.

SUBJECT INDEX TO VOLUME III, 1961

In this index, the following words have been dropped wherever they occur as first words of a title: the, a, an, of, on. Except for the title listings, the following also have been dropped: study of, problem of, experiment in, results of. The first word of the pertinent title is capitalized, except when the subject entry is extremely abbreviated, including only those words of the title needed to indicate scope of the article. Japanese and Chinese authors are given with surname capitalized to avoid confusion.

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